CALIFORNIA INVENTORY

PROCEDURES and TECHNIQUES REFERENCE DOCUMENTATION

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INVENTORY DESIGN

The California inventory design is a double sample for stratification based on the design described by Cochran(1977), but differing in that both the primary and secondary samples are on permanent grids. The primary sample was selected by dividing the State into squares 1369 meters (.85 mile) on a side and then selecting a random point within each square in the grid. Each of these primary sample points (often referred to as photo interpretation points, PI points, or photo plots) represents approximately 187 hectares (462 acres). Every fourth row on the primary sample grid was selected for the secondary sample (referred to as the field sample, field plot or ground plot). Thus, every sixteenth primary sample point became a field plot, and will represent thousands of acres. The squares selected for field examination were divided into two alternating sets. On the first set, each square was searched for the presence of inventory plot locations from the previous inventory. If such a plot was present, the PI point was moved to that location and became a field plot. If no existing Forest Inventory and Analysis (FIA) field plot was present, the square was searched for Soil Conservation Service (SCS)plots. If one was present, the PI plot was moved as above and became a field plot. If neither FIA nor SCS plots were present in the square, the original PI plot became a field plot location. The second set of squares was treated in the same manner as the first except the SCS location was given priority over the FIA location.

For more details regarding the sampling design please refer to **Appendix B.**
For a historical overview of data processing methods at previous inventory see **Appendix A.**

PRIMARY SAMPLE

In 1991-94, the California inventory area consisted of all land except public land managed by the USDA, Forest Service; and reserved land, such as National and State parks (public reserves), or Nature Conservancy areas (private reserves), etc.

Data collected in the primary sample are used to stratify both PI points and field plots. Land class stratum codes and owner class codes are the main classification variables used to do the stratifying. The end result is an estimate of stratum area and the area expansion factor for each plot.

Once the primary sample grid is established across the inventory area of a State, a new photo interpretation sample is usually collected for each successive inventory. In California, the North Coast resource area was handled in this way--with a new set of PI data collected on each PI sample point. A decision was made not to re-PI the other resource areas (North Interior, Sacramento, Central Coast, San Joaquin, and Southern units; see next page for justification). We will use the PI data collected from the previous inventory, with the exception of ownership data.

New ownership data was obtained from the California Department of Forestry--Forest and Rangeland Resources Assessment Program (CDF/FRRAP) for each of the primary points (P.I.points) in California. Since this data came from their GIS database, we anticipate some errors may exist due to possible inaccurately digitized coordinates in our data. Therefore, we will double sample for owner and allow the field plots to adjust for errors in the primary sample. The ownership data on the PI points will be accepted as true, however we will verify the owner on all points that are close to out-of-inventory boundaries. When the current inventory owner moved into or out of our inventory area (compared to the previous inventory owner), the owner was checked and verified. This may occur along the borders of NFS, census water, and reserved areas.

If for some reason FRRAP sent no ownership for a PI point, the previous inventory PI owner is accepted as the current owner. The ownership on all field plots will be checked through court house records, and known to be correct for the current inventory. Field plot owners are the second sample in the double sample design.

Background on the decision to change the photointerpretation strategy for the present inventory

The decision to use the Primary sample from previous inventory for the current inventory was made after an analysis of the North Coast data from both inventories (previous and current inventory--which were already collected). The overall result of that analysis showed that only minor changes occurred over the last inventory period (approx. 11 years) and caused a minor gain in the reduction of variance.

The data indicated that timberland area can be estimated just as efficiently with a double sample using the previous inventory PI as by re-PI'ing at current inventory. Although there are no equivalent data available to compare previous inventory and current inventory PI for volume stratification at the time of this analysis, the decision was made that the gains from a new PI would be marginal in the remaining areas of California (all of the state except the North Coast). The principal reason for detectable change in volume stratum is timber harvest--particularly clearcuts. Harvest, as practiced in California, is mostly partial harvest and this is often accomplished on existing road systems. It is our experience that such harvest is difficult to detect. For this reason, it is not expected that a re-PI would produce a large gain in the efficiency of volume estimation.

PRIMARY SAMPLE (continued)
Background on the decision to change the photointerpretation strategy for the present inventory

Forest condition and wildlife habitat are also assessed from the PI variables--stage of development, total density, and plant community. Although we lack hard data on the efficiency of these classifications for stratification, casual observation of past efforts has indicated a low correlation between PI and field estimates. In view of this and of our judgment that the California forests are usually lacking the discrete condition classes that permit easy identification on aerial photos, we believe that a rePI of these variables will not produce significant gains in efficiency.

We had plans to complete new PI-based inventories of land-use zone and of trees/acre on nonforest savannah. Because of design changes, neither inventory would have provided reliable estimates of change. We had also planned to re-PI chaparral areas but had planned no field effort. None of these projects is essential to the conducting of the regular inventories but were undertaken on a "while you are looking at the photos" basis. If the new PI is dropped they will only go forward if justified, on their own merits, for funding allocations. In any event, none of these three studies would necessitate a complete rePI. All could be restricted to areas of expected change.

In summary, a decision was made that inventory funds could be used most efficiently for some purpose other than a re-PI of California. A PI of the North Coast had already been completed when this decision was made, therefore the remaining resource areas (North Interior, Sacramento, Central Coast and the San Joaquin/Southern units) are affected by this decision and will not have a new primary sample collected. The current inventory then, consists of a current inventory PI on the North Coast and a previous inventory PI for the remainder of the state. At the time of the next cycle, a new stratification will probably be needed. This might take the form of a new PI or might be based on remotely sensed data from satellites.

The following pages summarize PI procedures for both previous inventory and current inventory. For complete details, refer to the PI Manuals on file in the CAP documentation room.

PREVIOUS INVENTORY PHOTOINTERPRETATION SUMMARY

Each PI point within the inventory area was examined to determine the general land class--whether it was Forest or Nonforest; if it was Forest, then whether it was Timberland or Other Forest. These land classes are further divided into the specific strata that exists within the land class. All of these land class combinations are coded and called 'Land Class Stratum' codes.

All land class areas must be at least .4 ha and 35 m wide, except for a portion of the Nonforest land classes. A smaller minimum of 5 meters and .4 hectares are required for constructed roads, railroads, powerlines, pipelines and canals, to allow them to qualify as Nonforest. Also, streams only need to be 10 m wide and .4 ha, to be classified as nonforest.

In all other cases, when the PI point falls in an area less than the 35m wide and .4 ha minimum (or less than the minimums just described above), the point will be classified according to the land class of the surrounding area.

If the land class is timberland, the point was examined closely to determine the volume stratum that exists within a 2 hectare area, where the owner class and stand condition are constant. Stand condition was defined by the topography, broad forest type, size class and stand density. To determine the volume strata, Photo Stand Volume Tables were consulted after an estimate of mean height of the dominant and codominant trees and the percent crown closure of the main canopy were obtained off of aerial photos. These tables provided an estimate of cubic volume per hectare, and allows each timberland PI point to be classified into the appropriate land class stratum (see following pages).

The percent cover of vegetation was determined on all points that were Forest, Improved pasture, Natural Rangeland and Naturally non-vegetated land.

All forest points were classified into the appropriate Resource zone.

All PI points have an owner code.

Codes used to classify photointerpretation points at the previous inventory

Resource zones

Code	Description
1	Main wildland resource zone--primarily timberland
4	Main wildland resource zone--primarily other than timberland
2	Low density residential/commercial, intensive agriculture
3	Towns and high density residential/developed

PREVIOUS INVENTORY PHOTOINTERPRETATION SUMMARY (continued)

Land class stratum codes
Timberland strata

Code	Description
21	Conifer volume 0-75 cubic meters/hectare. Includes mixed up messes, clearcuts, burns, brushfields.
22	All hardwood stands growing industrial size and quality roundwood with less than 10 percent conifer sawtimber crown closure.
23	Conifer volume 0-75 cubic meters/hectare. Obviously well-stocked stands of seedlings, saplings, or small poletimber conifer trees; obviously well stocked is 40 percent+ crown closure or evenly spaced stocking of small trees which will be 40 percent+ crown closure when they reach 17.5 cm.
24	Conifer volume 76-150 cubic meters/hectare.
25	Conifer volume 151-300 cubic meters/hectare.
26	Conifer volume 301-500 cubic meters/hectare.
27	Conifer volume 501+ cubic meters/hectare.

Other forest land strata

Code	Description
41	Rocky.
42	Subalpine or conifer scrub.
43	Pinyon-juniper.
44	Other forest oak--other hardwood.
45	Chaparral--10 to 49 percent cover.
46	Chaparral--50 percent or more cover.
47	Wetland, woodland, and bogs.
48	Cypress.
49	Low productivity.

Nonforest strata

Code	Description
61	Cropland.
62	Improved pasture.
63	Natural rangeland or abandoned farmland.
64	Other farmland including farmsteads.
65	Marsh.
66	Manmade nonforest stringers - 5 meters wide and wider constructed roads, powerlines, pipelines, canals, and railroads.
67	Urban - townsites and areas of clustered suburbs, residential and industrial buildings. (Forest .4 hectare or more in urban areas are classed as forest land. Zone codes are used to identify urban densities).
68	Nonvegetated - less than 10 percent vegetation - rock, sand, glaciers, streams 10 meters to 34 meters wide.
69	Christmas tree lands, nurseries.
92	Water - includes lakes .4 - 16 hectares and streams 35 meters - 200 meters wide.

PREVIOUS INVENTORY PHOTOINTERPRETATION SUMMARY (continued)

Cover class (2 digit code classified as follows)

Visible Crown Cover (first digit)

Code	Less than 10 percent crown cover:
1	No trees in 2 hectare circle
2	1 - 4 trees in 2 hectare circle
3	5 - 25 trees in 2 hectare circle
4	26 trees to 9 percent tree cover

When no trees are present

Code	More than 10 percent crown cover:
5	10 to 24 percent crown cover
6	25 percent plus crown cover

Majority Species (second digit)

Code	Species group
2	Conifer
3	Digger Pine
4	Hardwood
5	Pinyon-Juniper

1

Ownership class codes

Code	
	Public
11	National Forest
12	Bureau of Land Management
	Other Public
14	Miscellaneous Federal
15	State
16	County and municipal
	Forest Industry
21	Forest industry lands with mills (operating one or more wood-using plants that produce 100,000 board feet (or equivalent) annually)
71	Other Private Timber Growers (Forest industry without mills) Other private, managing timber and growing wood for industrial use; Do not operate a wood-using plant (tree farm).
	Farmer and Miscellaneous Private
44	Farmer, and miscellaneous private.
800	Indian tribal and allotted lands
	Reserved
08	Private reserved
09	Indian reserved
10	National Forest reserved
17	Other Federal reserved
18	State reserved
19	County reserved
	Unknown Owner - Nonforest
98	Census water
99	Unknown owner - nonforest

CURRENT INVENTORY PHOTOINTERPRETATION SUMMARY

A new PI was conducted over the 4 counties of the North Coast resource area for the current inventory in 1991. Most of the procedures are the same as the previous inventory PI just described above for the other resource areas. An area of .4 hectares around each P.I. point that fell within the inventory area was examined on aerial photos and placed in a land class. Land classes identified included nonforest, timberland, oak woodland, pinyon-juniper, subalpine or coastal scrub, other forest-low productivity, wetland, cypress, other forest--rocky, and other forest--unsuitable site, and chaparral. In addition, those points that had changed from forest to nonforest or vice versa were identified by photo comparison with the l981-84 inventory photos. In addition to land class, each point was placed in one of 4 resource zones, indicating the degree of agricultural, residential, or commercial development in the area near the point. Then each forest point was assigned a plant community, a stage of development code and a total tree density, as an aid to wildlife habitat classification.

PI plots with timberland present were further assigned a forest land stratum that indicated the presence or absence of a manageable stand of conifer, the stage of development of the stand, and whether or not there had been harvest activity since the last inventory. In addition, stand height and density were estimated for all conifer sawtimber stands (stage of development 3, 4, or 5). This information was used to sort conifer sawtimber PI plots into volume classes--see section on stratum collapse.

When PI plots straddled two or more land classes or forest conditions, the majority condition was interpreted and the percent of timberland area recorded.

Required timberland characteristics were recorded for all PI plots where the presence of timberland area was identified.

Stand height and density

Stand height and density were recorded for each PI plot classed as conifer timberland, (Forest land stratum equals 25) with stage of development 3, 4, or 5. Stand height was recorded in meters and stand density in percent. When two distinct canopy layers or two distinct stand size classes existed, the height and density of each was recorded.

Details of the PI class definitions and ownership collection procedures are found in the California PI manual, but a summary of the Items classified during a PI follows in the next few pages.

CURRENT INVENTORY PHOTOINTERPRETATION SUMMARY (continued)
Codes used to classify photointerpretation points for the current inventory

Resource zones

Code	Description
1	Main wildland resource zone--primarily timberland
4	Main wildland resource zone--primarily other than timberland
2	Low density suburban/farm
3	Urban/residential/developed

Forest land stratum codes

Code	Description
20	Plot area at least 25% but less than 75% timberland. (2-3 timberland points, indicates mixed condition classes present)
23	Plot at least 75% timberland at current inventory, <25% all live trees crown closure present at current inventory. (Brush, grass, poorly stocked conifer stands, heavily partial cut stands, unrestocked clearcuts).
24	Plot at least 75% timberland at current inventory and density of all live trees >25% but conifer density <25%. This code is intended for hardwood stands.
25	Plot at least 75% timberland at current inventory and >25% conifer crown closure present at current inventory. (Stands varying in stage of development but adequately stocked with established conifers).
41	Plot predominantly other forest, rocky.
42	Plot predominantly subalpine or conifer scrub.
43	Plot predominantly pinon-juniper
44	Plot predominantly other forest hardwood, and/or digger pine
45	Plot predominantly chaparral
47	Plot predominantly wetland
48	Plot predominantly cypress
49	Plot predominantly other forest--low productivity.
63	Plot predominantly natural rangeland, nonforest marsh, pasture, or abandoned farmland.
64	Plot predominantly other farmland i.e. croplands, farmsteads,etc.
66	Plot predominantly manmade nonforest stringers - constructed roads, powerlines, pipelines, canals, and railroads.
67	Plot predominantly urban - townsites and areas of clustered suburbs, residential and industrial buildings, city streets, developed parks. (Undeveloped forest land in parcels .4 ha and larger is classified as forest land. Zone codes are used to identify urban densities. All roads and streets that are within or border on urban areas are classed as urban)
68	Plot predominantly nonvegetated - less than 10 percent vegetation-rock, sand, glaciers, streams 10 meters to 34 meters wide.
69	Plot predominantly christmas tree lands, nurseries.
92	Plot predominantly water - includes lakes .4 - 16 hectares and streams 35 meters - 200 meters wide.

CURRENT INVENTORY PHOTOINTERPRETATION SUMMARY (continued)
Codes used to classify photointerpretation points for the current inventory

Stage of development

Code	Definition
0	Nonforest
1	Grass-forb/shrub/seedling
2	Sapling-pole
3	Small sawtimber
4	Large sawtimber
5	Mature and old-growth sawtimber

Plant communities (Forest land stratum must be 20-25 and Stage of Development = 2-5)

Code	Description
00	Nonforest
03	Mixed hardwood
04	Conifer-hardwood
08	Conifer
10	Chaparral
99	Forest less than 25% stocked

Tree count codes

Code	Number of trees	Code	Major Species
1	No trees	1	No trees
2	1 - 4 trees	2	Conifer
3	5 - 25 trees	3	Digger Pine
4	26 trees to 9 percent tree cover	4	Hardwood
		5	Pinyon Juniper

Percent of plot area qualifying for a tree count

Code	Proportion of plot
1	1- 9 %
2	10-19
3	20-29
4	30-39
5	40-49
6	50-59
7	60-69
8	70-79
9	80-89
10	90-99

CURRENT INVENTORY PHOTOINTERPRETATION SUMMARY (continued)
Codes used to classify photointerpretation points for the current inventory

Ownership codes

A. **Public Owners**	**Code**
1a.Region 5 National Forests	500
Angeles National Forest	501
Cleveland National Forest	502
Eldorado National Forest	503
Inyo National Forest	504
Klamath National Forest	505
Lassen National Forest	506
Los Padres National Forest	507
Mendocino National Forest	508
Modoc National Forest	509
Plumas National Forest	511
San Bernardino National Forest	512
Sequoia National Forest	513
Shasta-Trinity National Forest	514
Sierra National Forest	515
Six Rivers National Forest	510
Stanislaus National Forest	516
Tahoe National Forest	517
Lake Tahoe Basin Management Unit	519
1b.Region 4 National Forests	400
Toiyabe National Forest	417
1c.Region 6 National Forests	600
Rogue River	610
Siskiyou	611
2. **Other Public**	**Code**
Other Federal--reserved	7
Bureau of Land Management--reserved	10
Bureau of Land Management--available	12
Other Federal--available	14
State--available	15
County and Municipal--available	16
State--reserved	18
County and Municipal--reserved	19
Census Water	98
B. **Forest Industry**	
Forest Industry with mills	21
Forest Industry without mills	71
C. **Farmer and Miscellaneous Private**	
Private--reserved	8
Farmer owned	44
Miscellaneous Private--available	44
Indian, Tribal Lands	800
Native American--reserved	9
Native American--available	13

SECONDARY SAMPLE

The field plot layout and the data collected at the field locations are described in detail in the California field manual. What follows is a general overview with particular emphasis on those characteristics that affect data compilation.

In l981-84, a 5.5-kilometer (3.4 mile) grid was established across all ownerships. New 5-point field plots were established at each timberland grid location and at every fourth oak woodland, pinyon juniper, and chaparral location (11 k grid). The layout of these plots is described in the California field manual. In the 1981-84 inventory, care was taken to insure that all 5 points fell in a single land class and, if timberland, in a single condition-class. Points were moved or substituted as necessary to insure that condition-class boundaries were not crossed. Points 2-5 were moved if the point center fell in the same condition class as point 1, but either part of the 17 meter plot fell in a contrasting condition, or point center fell within 17 meters of a new condition. Moved points were positioned so the centers were at least 17m away from the contrasting condition. Points 2-5 were substituted if the point center fell in a different condition class than point 1. Substituted points were positioned in an entirely different location (more than 17m away) to an area that was in the same condition class as point 1.

In 1991-94, a new design was established which affects plot layout--plots are now laid out in a predetermined pattern, regardless of the condition class that exists on each subplot.

When a previous inventory subplot was moved away from a condition-class boundary (i.e. shifted slightly so the whole subplot fell in the same condition), a new subplot was installed in the original location and allowed to straddle the boundary. The old subplot was remeasured for use in estimating change between the previous and current inventories, but will not be remeasured again at the next inventory in the future.

If the old subplot was substituted at previous inventory (i.e. moved to an entirely new location), a new subplot was established in the predetermined pattern, and the old subplot was abandoned. If the condition class of the newly established subplot was the same condition class as on subplot 1 (at both previous and current inventory--i.e. the subplot was incorrectly moved), then the new subplot was labelled a "c" subplot and reconstructed to provide change information between previous inventory and current inventory. If the new subplot's condition-class was different than subplot 1 at either previous inventory or current inventory, then no reconstruction was attempted (this will probably be the more common situation).

The field plot design consists of 5 subplots arranged in a plus sign pattern oriented north-south-east-west. The bottom leg of the plus sign is 43 m and the other three legs are 64 m long. The five points are distributed over an area of approximately 1.6 ha. At each point, trees 17.5-90 cm are sampled with a metric 7-factor prism, trees .1-17.4 cm are sampled with a 3.3-m fixed-radius plot, and trees over 90 cm are sampled with a 17-m fixed-radius plot. The layout of these plots is described in the California field manual.

The current 1991-94 inventory in California is again being reinventoried and all 5-point plots on the 5.5-m grid are being revisited. Since, at this current inventory, subplots are neither being moved nor substituted, plots may sample two or more land classes or forest conditions.

- **The condition-class found at plot center (center of subplot # 1) is always coded as condition-class '1'.**

SECONDARY SAMPLE (continued)

Other condition-classes are numbered 2, 3, 4, 5 as they are encountered on the plot. The condition-class associated with each subplot center is recorded on the subplot attribute card. If two condition-classes (e.g. timberland vs. nonforest; or sawtimber vs. seedling/saplings) occur within one 17 meter fixed-radius subplot, the boundary between the two condition classes is delineated on the subplot diagram. In addition, the proportion of the subplot occupied by each condition-class is recorded (by counting dots on a diagram) and the condition-class associated with each tally tree is recorded. During compilation, these subplots and fractional subplots are summed to determine the proportion of each plot that falls in each condition-class. Each condition-class plot, then, has a complete set of area attributes and tree and volume statistics. The plot-expansion factor for each whole plot is subdivided into condition-class plot expansion factors -- one for each condition-class sampled. The condition-class plot expansion factor is the whole plot-expansion factor multiplied by the proportion of the plot that falls in that particular condition-class. **(See appendix C for an example of these calculations).**

Occasionally, a forest condition-class not sampled by any of the 5 subplot centers will be picked up on the outer portions of one or more of the 17-m fixed-radius subplots--these are called slivers. In such cases, forest type, stand size class, and stand age are entered in the field and calculation on these variables by computer algorithm should not be attempted.

CHANGE ESTIMATION

A primary use of continuous forest inventory plots is an analysis of the changes that occurred in area and volume over the remeasurement period. Most of the plots in California were remeasured unless they went to a reserved status or went out of the inventory area sampled by PRIME. However, because of a design modification for the current inventory, portions of a plot may not have been remeasured, and are not part of the change database. Estimates of change in area and volume were compiled from data on subplots established in 1981-84 that were in the same location in 1991-94. In addition, only data within condition class number 1 (the condition at the center of subplot 1) were valid for change estimation.

At the previous inventory, permanent five-subplot field plots were installed at timberland grid locations. At that time, all five subplots sampled a single homogeneous condition; if necessary, subplot locations were moved into the condition found at the center of the plot.

At the current inventory, the modified field plot design had a significant impact on the plot layout, the compilation of data, and the development of data for periodic change analysis. In the new plot layout, all five subplots were established in fixed positions and all conditions on a plot were sampled. If a plot straddled two or more conditions, the boundary around each condition was mapped and the conditions were sampled. Subplots were not moved for any reason. New subplots were installed in 1991-94 to replace previously moved subplots from the 1981-84 inventory.

Although five-subplot plots were established during both inventories, the locations may not coincide, thereby affecting the number of subplots available for remeasurement. Subplots installed in the previous inventory that were moved more than 56 feet (substituted subplots) were not remeasured in 1991-94. However, subplots that were only offset slightly in the previous inventory (subplots moved less than 56 feet) were remeasured and labeled as an ‘R’ subplot. In both cases, a new subplot ‘N’ was installed in the fixed position and used in current statistics only. Conditions other than the one found at the center of the plot were not remeasured because these conditions were not sampled at the previous inventory. The result of modifying the design is that plots used for change estimation may contain less than five subplots or include less than 100 percent of the plot area.

An outcome of the modified design is two databases, each containing different sets of condition class plots; one set contains all conditions and is used to produce current estimates of area and volume for 1991-94, and the second set contains only remeasured conditions on remeasured subplots and is used to produce estimates of change between the two inventories. Since condition class 1 is the only remeasured condition, it is the only condition in the change database.

Expansion factors for change plots may be different from those used in the current database. Thus, current inventory estimates from the ‘‘change’’ database differ slightly from those based on the new sample--the result of sampling error. The current database is more reliable for estimates of the current status of resources in 1991-94 but is less reliable for estimating periodic change, because it includes data not sampled in the earlier inventory.

Facts about the Change Database:
Condition Class ‘1’ only.
Remeasured subplots labeled as 11 to 55.
Reconstructed subplots labeled as C1 to C5.
Projected subplots labeled as P1 to P5.
Remeasured but not reestablished for future inventories labeled R1 to R5.
Plots that went out of the inventory labeled 01 to 05.

No ‘N’ subplots are used for change estimation.
Plot Weight is always 1.0 (or 100% of the plot area)

VEGETATION PROFILE

Vegetation data were collected at both the previous and current inventories. At the previous inventory, the percent cover of each species was determined for the whole 5-meter plot. At the current inventory, if the 5-meter plot straddles 2 condition classes, only the area within the condition class at subplot center is examined for the vegetation profile. The percent of the 5-meter plot that falls in this condition is recorded, and used to adjust or reduce the percent cover that is measured within this area. To summarize the vegetation data at current inventory, data from all veg-plots can be used. However, to analyze change in vegetation between occasions, we can only use the 5-meter vegetation profile plots that are 100% in condition class 1.

STATUS CODES FOR PROCESSING

The following are status codes used in the 1991-94 inventory of California. The codes are generated in program GETPL from the previous inventory and current inventory sample kind, adjusted ground land class and owner codes. These codes are used to identify the data records to include in each of the different compilation phases.

Status Code	Description	Processing
1	Forested at previous inventory; forested at current inventory	change and current
2	Forested at previous inventory; nonforest at current inventory	change and current
3	Nonforest at previous inventory; forested at current inventory	change and current
4	Nonforest at previous inventory; nonforest at current inventory	change and current
5	Forested at current inventor	current only
6	Nonforest at current inventory	current only
7	Forested at previous inventory; went out of inventory	change only
8	Nonforest at previous inventory; went out of inventory	change only
9	Out at previous inventory; out at current inventory	not change or current
10	Access denied timberland at current inventory; never visited	not change or current
11	Access denied oak/chapparal at current inventory; never visited	not change or current

Please note the following:

Condition class plots with status codes of 1,2,3,4,7 or 8 will be included in compilation of the change inventory.

Condition class plots with status codes of 1,2,3,4,5 or 6 will be included in compilation of the current inventory.

Condition class plots with status codes of 9, 10, or 11 are not part of either the change or current inventory.

LAND CLASS CODES USED TO CLASSIFY SECONDARY SAMPLE PLOTS

Code	Description
20	Timberland
41	Other forest--rocky
42	Subalpine or coastal conifer scrub
43	Pinyon-juniper
44	Oak woodland
45	Chaparral
47	Wetland
48	Cypress
49	Other forest, low productivity
63	Natural rangeland, nonforest marsh, pasture, abandoned farmland
64	Other farmland including farmsteads, cropland etc.
65	Marsh
66	Manmade cultural stringers--constructed roads, powerlines, pipelines, railroads
67	Urban land
68	Naturally nonvegetated land
69	Christmas tree lands, nurserys
92	Noncensus water

SAMPLE KIND CODES USED TO CLASSIFY SECONDARY SAMPLE PLOTS

SAMPLE_KIND is a condition class level variable.

Code	Sample kind	Description of sample kind
1	**Measured forestland**	Timberland (GLC 20); low productivity forest (GLC 49); oak woodland (GLC 44) on the 11k=Y or D grids; chaparral (GLC 45) on the 11k=Y or D grids in southern and central coast units.
5	**Access-denied**	Access-denied measured forestland that has not been harvested or disturbed since the previous inventory. Projected condition class plot -- measured at previous inventory but denied access at current inventory.
6	**Access-denied**	Access-denied measured forestland that has been harvested or disturbed since previous inventory. Projected condition class plot--measured at previous inventory but denied access at current inventory.
7	**Access-denied**	Timberland New timberland condition classes (GLC 20,49) never visited, that have no measured previous inventory information, and never before measured access has been denied. These are not projected, and drop out of the inventory.

Examples of sample_kind 7:

a.) New timberland (GLC 20 or 49) plots where no photo point qualifies for substitution, when attempting to reselect after a new plot was access denied.

b.) New timberland conditions (GLC 20 or 49) on subplots that were rotated at previous inventory. Plot now installed in standard configuration and part of the plot now falls in timberland.

8	**Access denied**	Oak woodland GLC=44 and on the 11K=Y or D Oak Woodland and grids, that are new at current inventory and access denied Chaparral at current inventory. There is no tree data collected, the condition class plots are not projected and drop out of the inventory. All access denied Chaparral GLC=45 on the 11K=Y or D grids, in the Central Coast and Southern survey units. (we can't project previous inventory data on remeasured chaparral plots, thus we don't need to code them separately from new plots).
9	**Nonforest and umeasured Forestland**	Nonforest and Ground land classes 41-43, 45-48, 63-92, and unmeasured forestland, oak woodland(44) not on the 11k grid includes access denied GLC 45's not on grid.
0	**Out of Inventory**	A condition class plot was not sampled in this inventory. The owner should be National Forest (500-519),reserved (7,10,18,19), census water (98) or out-of-resource area and/or out-of-state(999). The remainder of plot (not SK=0) should be treated as a partial plot for expansion factor and variance calculation.

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS

Each plot is assigned a site species and index height based on the best available site trees measured at Current inventory or, if needed, at Previous inventory or the first inventory (Occasion 1). Although, in rare cases, the site index may change with different condition classes on one plot, the extra effort required to collect site data for each separate condition class was not considered justified. The majority of plots with more than one condition class, have classes that are different because of human activity or other non-site related reasons. Therefore, by collecting site trees across the plot as a whole should provide an acceptable site index that crosses all condition class boundaries. We have only one set of site tree data and one site index for any given plot.

The equations used to calculate site index are referenced below. Mean annual increment is calculated by selecting the appropriate equation from those listed below, and multiplying the answer by the plant stockability factor. A factor of less than 1.0 indicates that the site is incapable of carrying normal levels of stocking, as defined by the appropriate normal yield table.

Note: the Mixed Conifer and Red Fir SI equations were originally developed for a base age of 50 years and total height. These equations were modified to use Breast Height Age for consistency in this inventory.

EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

<u>Please note that the following equations may use measurement units which are different than the units stored in the database for that variable</u>. *Bold italics* will alert users to these differences. Variables contained in the database will be noted in CAPITAL_LETTERS. We will modify all equations in the future to match the variable units in the database. For now, use caution.

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

1. Douglas-fir (202)--except in mixed conifer stands--and grand fir (17). Paper no. 8. l966. Site index curves for Douglas-fir in the Pacific Northwest" by James E. King. Weyerhaeuser Paper No.8.

$$si = \left(\frac{2500}{\left[\frac{\left[\frac{a^2}{(h*.3048) + 0.954038 - 0.0558178 * a + 0.000733819 * a^2} \right]}{0.109757 + 0.00792236 * a + 0.000197693} \right]} \right) + 4.5$$

where: *h* = HEIGHT
a = BREAST_HT_AGE
si = SITE_INDEX

The above equation is only useable when (1) the site trees were selected by King's method (not used at previous inventory) or (2) If the breast height age is greater than 50 years.

If neither of these two conditions exist, calculate McArdle's site index by one of the following equations:

If BREAST_HT_AGE < 40 yrs: $si_m = \left(e^{(3.3-(0.8*\ln[a]))*(0.96*(h*.3048)-2.66)} \right)$

If BREAST_HT_AGE >= 40 and < 100 yrs: $si_m = \left(e^{(2.1-(0.47*\ln[a]))*(0.96*(h*.3048)-2.66)} \right)$

where: *h* = HEIGHT
a = BREAST_HT_AGE
si_m = McArdle's site index
e( ) = Natural exponent
ln[ ] = Natural log

McArdle's site index is converted to King's site index by the equation (Weyerhaeuser Forestry Paper No. 8, James E. King, l966):

$$si_k = 21.5 - 0.18127(a + 8) + 0.72114 * si_m$$

where: *a* = BREAST_HT_AGE
si_k = King's site index
si_m = McArdle's site index

The source of the yield data is USDA Technical Bulletin 201 (rev l961) by R. E. McArdle. Yield capability will be calculated by the following equations:

a. When site index is < 75; $mai = -60.0 + 1.71 * (si)$

b. When site index is 75-130; $mai = -81.3 + 2.02 * (si)$

c. When site index is >130; $mai = 22.9 + 1.21 * (si)$

where: *mai* = Mean annual increment
si = SITE_INDEX

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

2. Mixed conifer (for all stands coded as Mixed Conifer). Note that this equation was originally developed and published using a base age of 50 years, total age and total height. The equations below were modified to accept Breast Height Age, the variable that our inventories normally measure.

Site species that can be used include: Douglas-fir (202), bigcone Douglas-fir (201), White fir (15), Ponderosa pine (122), Jeffrey pine (116), Shasta red fir (21), California red fir (20), and Coulter pine (109). Although sugar pine (117) is not a preferred site species, if it is recorded as a site tree--the mixed conifer equation is used.

Site index is from Dunning and Reineke. 1933. USDA Tech. Bull. 354.

$$si = (h*.3048)*\left(0.25489 + \left(\frac{29.37}{a}\right)\right)$$

$$mai = e^{\left(0.578265*si^{0.4}+1.8108\right)}$$

where: *si* = SITE_INDEX
h = HEIGHT
a = BREAST_HT_AGE
mai = Mean annual increment
e( ) = Natural exponent

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

3. Noble fir (22), Shasta red fir (21), subalpine fir (19), white fir (15), and mountain hemlock (264) - from Herman, Curtis and DeMars. Research paper PNW-243. 1978.
Note: when Shasta red fir and white fir are in mixed conifer stands, then use equation number 2--for mixed conifers.

a. For site trees 100 year or less:

$$si = \left(4.5 + 0.2145 * (100 - a) + 0.0089 * (100 - a)^2\right) + \left(\frac{1.0 + 0.00386 * (100 - a) + 1.2518 * (100 - a)^2}{10^{10}}\right) * \left((h * .3048) - 4.5\right)$$

where: *h* = HEIGHT
si = SITE_INDEX
a = BREAST_HT_AGE

b. For site trees > 100 years

$$si = \left(-62.755 + 672.55 * \left(\frac{1}{a}\right)^{0.5}\right) + \left(0.9484 + 516.49 * \left(\frac{1}{a}\right)^2\right) * \left((h * .3048) - 4.5 + \left(-0.00144 + 0 / 1442 * \left(\frac{1}{a}\right)\right) * \left((h * .3048) - 4.5\right)^2\right)$$

where: *h* = HEIGHT
si = SITE_INDEX
a = BREAST_HT_AGE

Yield capability is calculated by the equation:

$$mai = 1.6 * (si) - 50$$

where: *mai* = Mean annual increment
si = SITE_INDEX

The yield data were taken from USDA Technical Bulletin 1273. 1962. "Yield of even-aged stands of western hemlock," by George H. Barnes.

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

4. Ponderosa pine (122), Jeffrey pine (116), Coulter pine (109), Bishop pine (120).
Note: when these species are in mixed conifer stands, use equation number 2 for mixed conifers.

For site trees less than 130 years old--breast high age--site index is calculated from Research Paper PNW-232. l978. "Height, growth, and site index curves for managed even-aged stands of ponderosa pine in the Pacific Northwest," by James W. Barrett.

$$si = 104.93 - \left[1.198632 - 0.0283073 * (a) + \frac{8.44441}{a}\right] * \left[128.8952205 * \left(1 - e^{-0.016959} * (a)\right)^{1.23114}\right] + \left[\left(1.198632 - 0.00283073 * (a) + \frac{8.44441}{a}\right) * \left((h * .3048) - 4.5\right)\right]$$

where: *si* = SITE_INDEX
a = BREAST_HT_AGE
h = HEIGHT
e( )= Natural exponent

For ponderosa pine over 130 years in age, we will use the equation :

$$si = \left[\left(5.328 * (a)^{-0.1} - 2.378\right) * \left((h * .3048) - 4.5\right)\right] + 4.5$$

where: *a* = BREAST_HT_AGE
h = HEIGHT

(This approximates Meyer in USDA Tech. Bull. 630.)

Yield capability will be calculated by the equation:

$$mai = e^{\left(0.702695 * (si)^{0.42} - 0.51367\right)}$$

where: *mai* = mean annual increment
e( ) = natural exponent

The source of the yield data is also Meyer (1961).

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

5. California red fir (20) - from Schumacher, F.X. 1928. "Yield, Stand and volume tables for red fir in California." Bull. 456. Univ. of California. Berkeley, CA.

Note that this equation was originally developed and published using a base age of 50 years, total age and total height. The equations below were modified to accept Breast Height Age, the variable that our inventories normally measure.

When California red fir is coded as being in a mixed conifer stand, then use equation number 2-- for mixed conifers.

Site index approximated by equation:

$$si = (h * .3048) * \left(0.1464 + 43.3273 * (a)^{-1.1}\right)$$

where: *a* = BREAST_HT_AGE
h = HEIGHT
si = SITE_INDEX

Yield capability is calculated by:

$$mai = 48.278 + 0.23638 * si^{1.6}$$

where: *mai* = mean annual increment
si = SITE_INDEX

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

6. Redwood (211) - Krumland, Bruce; and Wensel, Lee. 1979. "Diameter distribution models for coastal stands in California." Cooperative Redwood Yield Research Project Research Note No.11.

Site index is calculated using the following table:

BREAST HEIGHT AGE	50	60	70	80	90	100	110	120	130	140	150	160 SITE INDEX
				HEIGHT in DECIMETERS								
30	118	139	160	181	202	224	246	267	290	312	335	357
35	132	155	179	203	227	251	275	299	324	349	374	399
40	144	170	196	223	249	275	302	329	356	383	410	437
45	156	185	213	241	270	299	327	356	385	413	442	471
50	168	198	229	259	290	320	351	381	411	442	472	503
55	179	211	243	276	308	340	372	404	436	468	500	532
60	189	223	257	291	325	359	393	426	459	493	526	559
65	199	235	271	306	341	377	412	446	481	515	550	584
70	209	246	283	320	357	393	429	465	501	536	572	607
75	218	257	295	333	371	409	446	483	520	556	592	628
80	226	267	306	346	385	424	462	500	537	574	611	648
85	235	276	317	358	398	437	477	515	554	592	629	666
90	243	285	328	369	410	450	490	530	569	608	646	684
95	250	294	337	380	422	463	503	544	583	622	661	700
100	258	303	347	390	432	474	516	557	597	636	676	714
105	265	311	355	400	443	485	527	569	609	650	689	728
110	272	318	364	409	453	496	538	580	621	662	702	741
115	278	326	372	417	462	506	549	591	632	673	714	754
120	284	333	380	426	471	515	558	601	643	684	725	765
125	290	339	387	433	479	524	568	611	653	694	735	775
130	296	346	394	441	487	532	576	620	662	704	745	785
135	302	352	401	448	495	540	584	628	671	713	754	795
140	307	358	407	455	502	547	592	636	679	721	763	803
145	312	363	413	461	508	554	599	644	687	729	771	811
150	317	369	419	467	515	561	606	651	694	736	778	819
155	322	374	424	473	521	568	613	657	701	743	785	826
160	326	379	430	479	527	574	619	664	707	750	792	833
165	331	384	435	484	532	579	625	670	713	756	798	839
170	335	388	440	489	538	585	631	675	719	762	804	845
175	339	392	444	494	543	590	636	681	724	767	809	851
180	343	397	449	499	547	595	641	686	730	772	814	856
185	346	401	453	503	552	599	645	690	734	777	819	861
190	350	404	457	507	556	604	650	695	739	782	824	865
195	354	408	461	511	560	608	654	699	743	786	828	869
200	357	412	464	515	564	612	658	703	747	790	832	873
205	360	415	468	519	568	616	662	707	751	794	836	877
210	363	418	471	522	571	619	665	711	755	797	839	881
215	366	421	474	525	575	623	669	714	758	801	843	884
220	369	424	477	529	578	626	672	717	761	804	846	887
225	372	427	480	532	581	629	675	720	764	807	849	890
230	374	430	483	534	584	632	678	723	767	810	852	893
235	377	433	486	537	587	634	681	726	770	812	854	895
240	379	435	488	540	589	637	683	728	772	815	857	898
245	382	437	491	542	592	639	686	731	775	817	859	900
250	384	440	493	545	594	642	688	733	777	819	861	902
255	386	442	496	547	596	644	690	735	779	822	863	904
260	388	444	498	549	598	646	692	737	781	824	865	906
265	390	446	500	551	601	648	694	739	783	825	867	907
270	392	448	502	553	602	650	696	741	785	827	869	909
275	394	450	504	555	604	652	698	743	786	829	870	911
280	396	452	505	557	606	654	700	744	788	830	872	912
285	397	454	507	558	608	655	701	746	789	832	873	913
290	399	455	509	560	609	657	703	747	791	833	874	915
295	401	457	510	562	611	658	704	749	792	834	876	916
300	402	458	512	563	612	660	706	750	793	836	877	917

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

6. Redwood (211) continued

Redwood yield capability is determined by the equation:

$$mai = e^{\left(0.2995*\sqrt{si}+2.404\right)}$$

where: *mai* = mean annual increment
si = SITE_INDEX
e( ) = Natural exponent

The source of the yield data is "Empirical yield tables for young-growth redwood", Lindquist & Palley, 1963. Calif. Agric. Exper. Sta. Bull. # 796.

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

7. Lodgepole pine (108) and western white pine (119) - from Dahms, Walter G. 1975. "Gross yield of Central Oregon lodgepole pine". In: Management of lodgepole pine ecosystems--symposium proceedings. Washington State University Cooperative Extension Service. Pullman, WA.

Site index can be approximated from the equation:

$$si = \left(72.68 - 8.8*(a)^{0.45}\right) + 4.5 + \left(2.2614 - 1.26489\left[1 - \left(e^{-0.08333}\right)*a\right]^{5}\right)*\left(\left(h*.3048\right) - 4.5\right)$$

where: *si* = SITE_INDEX
h = HEIGHT
a = BREAST_HT_AGE

therefore:

$$mai = 0.8594 * si - 22.32$$

where: *mai* = Mean annual increment
si = SITE_INDEX

The yield data is from Dahm's "Gross and net yield tables for lodgepole pine," 1964, Research Paper PNW-8. (use in California, E.Oregon and western Washington)

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

8. Western Hemlock (263) and Sitka Spruce (98)-The site index equation used is from Weyerhaeuser paper no. 17. 1978. "Site index tables for western hemlock in the Pacific Northwest", by Kenneth N. Wiley.

Site index is based on breast height age of 50 years.
If Trees <= 120 years in age:

$$si = 2500\left\{\frac{\left[\left(\left(h*.3048\right)-4.5\right)*\left(0.1394+0.0137*\left(a\right)+0.00007*\left(a\right)^{2}\right)\right]}{\left[\left(a\right)^{2}-\left(\left(h*.3048\right)-4.5\right)*\left(-1.7307-0.0616*\left(a\right)+0.00192*\left(a\right)^{2}\right)\right]}\right\}+4.5$$

where: *si* = SITE_INDEX
h = HEIGHT
a = BREAST_HT_AGE

If Trees > 120 years age, use the 50-year index equation from Barnes below:

$$si = 4.5 + 22.6 * e^{\left(\left(0.014482-0.001162*\ln\left[a\right]\right)\left(h*.3048\right)-4.5\right)}$$

where: *si* = SITE_INDEX
h = HEIGHT
a = BREAST_HT_AGE
ln[ ] = Natural log
e( ) = Natural exponent

Yield capability is:

$$mai = 2.628 * si - 49.8$$

where: *mai* = Mean annual increment
si = SITE_INDEX

The source of the yield data is USDA Technical Bulletin 1273. 1962. "Yield of even-aged stands of western hemlock" by George H. Barnes.

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

9. Red alder (351) in all counties (and other hardwoods if needed)--Site index is taken from PNW Research Paper no.36. 1960. "Normal yield tables for red alder," by Norman P. Worthington et.al.

$$si = \left(0.60924 + \frac{19.538}{a}\right) * \left(h * .3048\right)$$

where: *a* = BREAST_HEIGHT_AGE
h = HEIGHT

Yield capability for ALL HARDWOODS will be calculated from the equation:

$$mai = 1.7102 * \left(si\right) - 53.1279$$

where: *mai* = Mean annual increment
si = SITE_INDEX

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

10. Black cottonwood (747), Fremont poplar (748) -- Site index is from an informal study by C. Bolsinger--3/6/74 memo to Berger et. al.

SITE_INDEX = 92.0

Yield capability for ALL HARDWOODS will be calculated from the equation:

$$mai = 1.7102 * (si) - 53.1279$$

where: *mai* = Mean annual increment
si = SITE_INDEX

The data for the yield equation were also taken from Worthington (l960).

SITE INDEX AND MEAN ANNUAL INCREMENT EQUATIONS
EQUATIONS FOR CALCULATING SITE INDEX AND YIELD CAPABILITY

11. Western redcedar (242) --The site index equation is from Kurucz, J.F. 1985. Metric SI for red cedar stands. MacMillan Bloedel Ltd., Woodlands Serv. Div., Nanaimo, B.C. Unpubl. Rep.

Although western redcedar is rarely chosen for a site tree, if it is recorded, use the following equations:

If age <= 50 years, then:

$$si = \left(\frac{2500}{.3048}\right) * \left\{ \frac{\left[\left(\left(h * .3048\right) - 1.3\right) * \left(0.05027 + 0.01411 * \left(a\right)^2\right)\right]}{\left[\left[a^2 - \left(\left(h * .3048\right) - 1.3\right) * \left(-3.11785 * \left(a\right) + 0.00174 * \left(a\right)^2\right)\right]\right]} \right\} + 4.5$$

where: *si* = SITE_INDEX
h = HEIGHT
a = BREAST_HT_AGE

If age > 50 years, then:

substitute h_a for variable *h*.
h_a is calculated using equation (18).

$$h_a = h + 0.023798545 * \left(h\right) - 0.000475909 * \left(a\right) * \left(h\right)$$

Yield capability will be calculated by the equation:

$$mai = 2.628 * \left(si\right) - 49.8$$

where: *mai* = Mean annual increment
si = SITE_INDEX

The source of the yield data is USDA Technical Bulletin 1273. l962. "Yield of even-aged stands of western hemlock" by George H. Barnes.

SITE PRODUCTIVITY--CUBIC FOOT SITE CLASS

Cubic-foot site class is determined by assigning the plot to the appropriate class, based on the MAI as adjusted by the plant stockability factor. The classes are as follows:

Site Class	Mean Annual Increment (cubic foot volume per acre per year)
1	225 or more
2	165 to 224
3	120 to 164
4	85 to 119
5	50 to 84
6	20 to 49
7	Less than 20

DUNNINGS SITE INDEX CONVERSION

Dunnings site index can be derived from the regular site index using one of the following equations (the site index is in feet):

Site index equations	Conversion Equation
1 and 8	$dsi = 3.07 * \left(si^{0.9}\right)$
2, 5 and 6	$dsi = 4.74 * \left(si^{0.82}\right)$
7	$dsi = 1.75 * \left(si^{0.96}\right)$
3 and 4	$dsi = 1.54 * \left(si^{0.98}\right)$
9,10, and 11	$dsi = 0.0$

where: dsi = Dunninds site index
si = SITE_INDEX

ESTIMATING ANNUAL SQUARED DIAMETER GROWTH ON TIMBERLANDS

<u>Please note that the following equations may use measurement units which are different than the units stored in the database for that variable</u>. Variables contained in the database will be noted in CAPITAL_LETTERS.

These equations are calculated using centimeters (cm.) The database stores diameter breast height information in millimeters (mm.) The conversion to centimeters is accomplished by the following:

DBH_MM / 10 = diameter breast height in centimeters (cm.)

Note: *asdg* means Annual Squared Diameter Growth

1. Estimating annual squared diameter growth for all tree species that are < 12.5cm diameter breast height and/or < 20 years old at current inventory:

asdg = Diameter breast height in centimeters (cm.) / Breast height age

For all other trees that are >=12.5cm diameter breast height and >= 20 years old at current inventory, use the following equations as appropriate for species, diameter ranges, as shown below:

2. When 2 diameter measurements are available and diameter breast height is >= 12.5 cm and >=20 years old, then:

$$asdg = [((dbh\_cm)^2 - (prev\_dbh\_cm)^2)] / REMSRT\_PERIOD$$

where: prev_dbh_cm = previous inventory diameter breast height in cm.
REMSRT_PERIOD = Remeasurement period in years: between previous and current inventory, or prior and current inventory

3. When the previous inventory diameter breast height is missing (only 1 measured diameter available) then annual squared diameter growth will be estimated with the following equations, on trees where the diameter breast height is >=12.5cm, and age is >=20 years old for the North Coast, Central Coast, North Interior and Sacramento combined, and Southern and San Joaquin combined:

The first step is to adjust the site index to a common base year of 50 years and create a variable named si50

If MIXED_SWD_SITE_YN = Y then si50 = SITE_INDEX * 1.187

If SITE_SP = (22, 21,19,15,122,116,109,108,119) then si50 = SITE_INDEX * .6

If SITE_SP = 20 then si50 = SITE_INDEX * 1.3654

If SITE_SP = 351 then si50 = SITE_INDEX * 1.1

else si50 = SITE_INDEX

SITE_SP is the site species.

ESTIMATING ANNUAL SQUARED DIAMETER GROWTH ON TIMBERLANDS **(continued)**

North Coast

Terminology and variables used in all the equations:

bhage = breast high age, in years
dbh3= diameter at breast high, **<u>in centimeters</u>**
dbhage = (dbh3**2 / bhage3) current inventory
crownr3 = crown ratio at occ3
exp= natural exponent

Please note ** in equations (we did not superscript them in this section)
Please note that if asdg < 0 then asdg = .1

Terminology and variables used for softwoods only:

term = [(dbh3**.4220943944) * (crownr3**.2259655973)]

Terminology and variables used for hardwoods only:

nlogdage = natural log(dbhage)
nlogdbh = natural log(dbh3)
nldterm = [(nlogdbh**.5101080088) * (crownr3**.2168090998)]

SOFTWOODS

A. FOR diameters >=12.5 cm and < 20 cm (and bhage > 20)

REDWOOD: asdg = (-1.72934268 + 0.09620936*dbhage + .71885378*term)**2
OTHER SOFTWOODS: asdg = (-2.37038055 + 0.09195063*dbhage +1.01309585*term)**2

B. FOR diameters >=20 cm and <=110 cm:

REDWOOD: asdg = (-2.66202655 + 0.03745907*dbhage +1.05175868*term)**2
DOUGLAS FIR: asdg = (1.06696816 + .05416993*dbhage + .49721009*term)**2
OTHER SOFTWOODS: asdg = (.16342696 + .05032318*dbhage + .61045100*term)**2

C. FOR diameters > 110 cm:

REDWOOD: asdg = (-1.22534270 + 0.02275140*dbhage +1.03995218*term)**2
OTHER SOFTWOODS: asdg = (5.58096190 + 0.05046164*dbhage)**2

HARDWOODS

For species 361, and all > 800:

asdg = exp(-2.49649036 + 1.24712280*nldterm + .60784806*nlogdage)

For species 351 (Alder):

asdg = exp(-2.09756175 + 0.94726743*nldterm + .83278141*nlogdage)

For species 631, 312, 431, and all other hardwoods not listed:

asdg = exp(-2.50551716 + 1.33184695*nldterm + .58204367*nlogdage)

ESTIMATING ANNUAL SQUARED DIAMETER GROWTH ON TIMBERLANDS (continued)

CENTRAL COAST

dbh3 >=12.5 (remember this is centimeters)
bhage3 >=20
(log=natural log)
ndbh2 = (log(dbh))**2
nlogdage = log (dbh**2/age)
nelev = log(elev)
nlogdbh = log(dbh)
si50 = site index converted to the common base year of 50 years
n1overd= 1/(log(dbh))
if spp < 300 then term=(nlogdbh**.78 * crownratio**.176)
if spp > 300 then term=(nlogdbh**.4988 * crownratio**.224)

SOFTWOODS

if spp = 211:
asdg=exp(- 3.2485 + .768237*nlogdage + 1.25179*term -.046*ndbh2)
if spp = 202:
asdg=exp(1.986 + .8396*nlogdage + .9227*term - .158*ndbh_mm2 - 8.657*n1overd)

other softwoods:
asdg=exp(- 2.1320 + .6848*nlogdage + 1.2442*term-.0886*ndbh2)

HARDWOODS

if spp=631:
asdg=exp(- 3.1173 + .9007*nlogdage + 1.598 *term -.0848*ndbh2)

if spp = 801, 805, 839
asdg=exp(- 7.6291 + 1.0395*nlogdage + 1.604 *term + 9.2056*n1overd)

if spp > 800 and spp < 900 (other oaks, not 801,805,839)
asdg=exp(.5898 + 1.4553*term -7.6551*n1overd)

if spp=361
asdg=exp(-.5265 + .7363*nlogdage + 1.4953*term -.1058*ndbh2 - 5.7638*n1overd)

if other hardwoods
asdg=exp(- 2.4560 + 1.0205*nlogdage + 1.199 *term -.0928*ndbh2)

ESTIMATING ANNUAL SQUARED DIAMETER GROWTH ON TIMBERLANDS (continued)

NORTH INTERIOR AND SACRAMENTO UNITS COMBINED

dbh3 >=12.5 (remember this is centimeters)
bhage3 >=20
(log=natural log)
ndbh2 = (log(dbh))**2
nlogdage = log (dbh**2/age)
nelev = log(elev)
nlogdbh = log(dbh)
si50 = site index converted to the common base year of 50 years

if spp < 300
term=(nlogdbh**.8124 * crownratio**.0968)
if spp > 300
term=(nlogdbh**.7117 * crownratio**.0076)

SOFTWOODS
if spp < 23
asdg = exp(-4.0729 + .6433*nlogdage + 2.3909*term - .1869*ndbh2)

if spp= 81
asdg = exp(-4.4466 + .6964*nlogdage + 2.2891*term - .1939*ndbh2 + .0068*si50)

if spp= 100 - 130
asdg = exp(-3.9161 + .7910*nlogdage + 1.9866*term - .1696*ndbh2 + .00404*si50)

if spp=202,211
asdg = exp(-2.3742 + .8848*nlogdage + 1.4157*term - .12115*ndbh2)

if other softwoods
asdg = exp(6.0549 + .4597*nlogdage + 1.1044*term - 1.1464*nelev)

HARDWOODS
if spp = 818
asdg = exp(-13.9876 + .4110*nlogdage + 18.1344*term - 8.3783*nlogdbh)

if other hardwoods
asdg = exp(.1290 + .87225*nlogdage)

ESTIMATING ANNUAL SQUARED DIAMETER GROWTH ON TIMBERLANDS (continued)

SOUTHERN AND SAN JOAQUIN UNITS COMBINED

dbh3 >=12.5 (remember this is centimeters)
bhage3 >=20
(log=natural log)
ndbh2 = (log(dbh))**2
nlogdage = log (dbh**2/age)
nelev = log(elev)
nlogdbh = log(dbh)
si50 = site index converted to the common base year of 50 years
crcc = crownratio*crownclass
nterm = log (crownratio*dbh)

SOFTWOODS
if spp eq 81
asdg = exp(- .4095 + .8894*nlogdage + .1643*crownratio)

if spp > 115 and <123
asdg = exp(- 2.4003 + .7825*nlogdage + .5902*nterm)

if spp < 23
asdg = exp(- 3.190 + .6888*nlogdage + 1.4192*nterm - .1826*ndbh_mm2 -.04098*crcc)

if other softwoods
asdg = exp(4.9088 + .8982*nlogdage - .8545*nelev + .2467*crownratio)

HARDWOODS
if spp = 818
asdg=exp(- 1.4111 + .3673*nlogdage + .6924*nterm - .0853*crcc +.116*crownratio)

if other hardwoods
asdg=exp(3.5572 + .7129*nlogdage - .6702*nelev + .3281*nterm)

ANNUAL SQUARED DIAMETER GROWTH ON OAK WOODLANDS

OAK WOODLAND PLOTS -- ALL SURVEY UNITS

trees < 12.5cm dbh, or breast_ht_age < 20 years:

asdg = (dbh**2) / breast_ht_age

trees >= 12.5cm dbh, and breast_ht_age >= 20 years:

asdg < 0 then asdg = .1

HARDWOODS

species => 800 and survey unit is 1,2,3, then:

asdg = exp (-1.66461986 + 1.23778275*(ln(dbh)))

species => 800 and survey unit is 4,5,6 then:

asdg = exp (-.56190443 + .68815557*(ln(dbh)) + .31654258 * (ln(dbhage)))

for all other hardwood species > 300 and < 800 for all survey units:

nterm=ln(dbhage))**.2852427943 * ln(dbh)**.5841465648

asdg = exp (-1.64299935 + 1.62864479*nterm);

all conifers, species < 300, on all survey units:

asdg=exp(1.28690442 - .55047284*(ln(dbh)) + 1.24899232*(ln(dbhage)));

where: ln(dbhage) = natural log of dbh**2/breast_ht_age

ln(dbh) = natural log of dbh

Note: asdg is calculated with current inventory variables and data. If there are no current inventory data available (i.e. when dbh_mm is missing), then asdg from the previous inventory (occaision 2) will be estimated. To get these estimates, substitute either previous inventory or prior inventory (occaision 1) data in the above equations to calculate asdg. These are used in the equations in the following section - estimating a missing tree diameter - when predicting dbh on projected (access-denied) plots or on harvested-remeasured plots.

ESTIMATING A MISSING TREE DIAMETER

1. To estimate DBH2, annual squared diameter growth will be subtracted from DBH_MM**2.

DBH2 = SQRT [(DBH_MM**2) - (ANN_SQRD_DIAM_GRW_CM2 * REMSRT_PERIOD)]

Where:	ANN_SQRD_DIAM_GRW_CM2	= Annual squared diameter growth calculated with CURRENT INVENTORY tree attributes
	REMSRT_PERIOD	=remeasurement period in years between PREVIOUS INVENTORY and CURRENT INVENTORY

2. To estimate DBH_MM on PROJECTED plots, annual squared diameter growth will be added to DBH2**2 as follows:

DBH_MM = SQRT [(DBH2**2) + (ASDG2 * REMSRT_PERIOD)]

Where:	ASDG2	= Annual squared diameter growth calculated with PREVIOUS INVENTORY tree attributes
	REMSRT_PERIOD	= remeasurement period in years between PREVIOUS INVENTORY and CURRENT INVENTORY

3. To estimate DBH_MM on HARVESTED--REMEASURED plots:

Trees harvested since PREVIOUS INVENTORY will need ASDG2 calculated, using the appropriate equation described above for one missing diameter. If a measured PREVIOUS INVENTORY DBH is available, use PREVIOUS INVENTORY tree attributes in the ANN_SQRD_DIAM_GRW_CM2 equations. ASDG2 can be calculated with the equations below:

At time of harvest:

DBH_MM = SQRT [(DBH2**2) + (ASDG2 * Years to Harvest3)]

Where: ASDG2	= Annual squared diameter growth calculated with PREVIOUS INVENTORY tree attributes
Years to Harvest3	= years from PREVIOUS INVENTORY to date of harvest

COMPILATION NOTE: trees measured at Current inventory that had a measured increment, were projected back using that increment. If the result produced an Previous inventory DBH <2.5 cm (i.e. a seedling), then the DBH2 was set to 0, but the ASDG was set for future projections. On these trees, the AHG is not computed.

PROJECTED TREE HEIGHTS

Whenever available, field-entered tree heights will be used. When a tally tree has no current inventory height but has an previous inventory height or vice versa, the missing height will be projected, using height growth curves based on site index studies (SI-Estimated Height). Calculation of missing heights will differ depending on species and tree characteristics--there are a set of equations for each of the following conditions when one measured height is available: seedlings; trees <30 years old and < 12.5 cm in diameter; and trees >= 30 years old and >= 12.5cm dbh. In addition, there are equations to use when NO measured height is available at either occasion.

The first step in estimating a missing height is to calculate an estimated height using equations derived from site index studies. These are referred to as 'SI height equations', where one equation is used for a group of species.

The table below indicates which equation should be used for each species. These heights are estimates calculated from general equations published for each species as part of site index studies.

SITE INDEX HEIGHT ESTIMATION EQUATIONS

SOFTWOODS:

Equation Number	Species code	Species name
1	202, 017, 201	Douglas-fir, grand fir, bigcone Douglas-fir
5	98, 263, 231, 251	yew, western hemlock, Sitka spruce
	242, 41, 42, 81, 50, 64	all cedars, cypress, nutmeg, juniper
6	103, 109-117, 120-127, 104, 102, 133	all pines EXCEPT lodgepole, whitebark, W.white
7	101, 108, 119	lodgepole, whitebark, western white pines
9	14, 15, 19-22, 92, 93, 264	true firs, EXCEPT grand, Mountain hemlock, Engelmann spruce, brewer spruce
10	211, 212	redwood, giant sequoia

HARDWOODS:

Equation Number	Species code	Species name
4	312, 330, 351, 352, 492	maple, buckeye, red and white alder, dogwood
	542, 746-748, 920, 510	ash, aspen, poplar, cottonwood, cherry
	374	water birch
8	341, 361, 431, 600-730, 801-839, 981-999	madrone, chinkapin, walnut, tanoak, apple, sycamore, all oaks, willow, Cal.laurel, others

HE--(SI Estimated Height) is calculated from one of the following equations, depending upon the tree species. The number in front of each equation below relates back to the table above.
NOTE: These equations estimate height in FEET.

BREAST_HT_AGE is always age at breast height and SI is SITE_INDEX. (LN=natural log)

SOFTWOODS:
1. Douglas-fir (202) (California and western Oregon) -- Source: Curtis, Clendenen, and DeMars. "...DFSIM User's Guide" GTR PNW-128

HE = [SI] * exp[b2((BREAST_HT_AGE + 13.25 - SI/20)b3 - (63.25 - SI/20)b3)]

Where:

b2 = LN[4.5/SI]/[(13.25 - SI/20)b3 - (63.25 - SI/20)b3]

b3 = -.477762 - .894427(SI/100) + .793548(SI/100)2 - .171666(SI/100)3

5. Western hemlock (263) Source: Weyerhaeuser paper no. 17. 1978. Site index tables for western hemlock in the Pacific Northwest", by Kenneth N. Wiley.

HE= 4.5+((BREAST_HT_AGE**2)/(-1.7307+.1394*Z+((-.0616+.0137*Z)*BREAST_HT_AGE)+((.00192+.00007*Z)*BREAST_HT_AGE**2)))

Where: Z = 2500/(SI - 4.5)

6. Ponderosa pine (122). Source: Barrett. Height growth and site index curves for managed even-aged stands of ponderosa pine in the Pacific Northwest. 1978. R. Paper PNW-232.

HE= 4.5 + 128.895 [1 - e(-.016959*(BREAST_HT_AGE))]1.23114

7. Lodgepole pine (108). Source: Dahms. Gross yield of central Oregon lodgepole pine. 1975. In: Proceedings--Management of lodgepole pine ecosystems symposium.

HE= 13.8 + 88.349888 [1 - e(-.0224875334*(BREAST_HT_AGE))]1.63814

9. Noble fir (022). Source: Herman, Curtis, and Demars. Height growth and site index estimates for noble fir in high-elevation forests of the Oregon-Washington Cascades. l978. Res. Paper PNW-243.

HE= 4.5 + 95.5/[1104.94 (BREAST_HT_AGE)-2 + 40.38 (BREAST_HT_AGE)-1 + 0.4857]

10. Redwood (211) - Krumland, Bruce; and Wensel, Lee. 1979. "Diameter distribution models for coastal stands in California." Cooperative Redwood Yield Research Project Research Note No.11.

HE = B1*[1 - (1 - (SI/B1)B3)*E((BREAST_HT_AGE - 50)*B2)]1/B3

Where: B1 = 9.44*SI.68
B2 = -.00118*SI.46
B3 = .64*SI.15

A second, older equation exists for Redwood. Colin MacLean referenced this equation, so for the time being, it will remain in the documentation, but was not used to estimate height.

Redwood (211). Source: derived from Krumland and Wensel. l977. Co-op redwood yield research project. Research Note # 5. "Procedures for estimating redwood and Douglas-fir for site indexes in the north coastal region of California.

HE= [216.26]*[1.0 - 0.62665 (e-0.0098(b.h.age))]* 0.7831]

HARDWOODS:
4. Red alder (351). Source: Worthington et. al. Normal yield tables for red alder. 1960. Research paper 36.

HE= 90/[.60924 + (19.538/(BREAST_HT_AGE + 2))]

8. California black oak (818). Source: Powers. Site index curves for unmanaged stands of California black oak. 1972. Res. Note PSW-262.

HE= 9.687*SQRT(BREAST_HT_AGE) - 18.497

EQUATIONS AND FACTORS TO ESTIMATE ANNUAL HEIGHT GROWTH WHEN ONE MEASURED TREE HEIGHT IS KNOWN

A. SEEDLINGS--0-2.4 cm dbh--All species--All survey units:
All seedlings will have a diameter recorded as "1", which indicates that the tree is less than 2.5 cm at breast height. Seedlings have a breast height age which can be 0 or some positive number. When a seedling is 0 at BH, it really has an actual or total age (the time it's taking to reach breast height).

Missing heights on any seedling will be estimated as follows: In the California inventory, we are not tracking seedlings, meaning that we did not try to find the exact previous inventory seedlings at current inventory. If previous inventory seedling data are needed, it is retrieved from the previous inventory data file. No current inventory seedlings are projected backwards to previous inventory. In the special case of a reconstructed "C" subplot, where we have no previous inventory seedling data we will do the following: set the previous inventory seedling data equal to current inventory seedling data collected on that subplot; and, if a sapling is projected backwards and becomes a seedling, then add this projected previous inventory seedling data (PREV_DBH_MM=1) to the other previous inventory seedlings.

Follow the rules below to obtain a height for the new previous inventory seedling. If a projection causes a sapling to become a seedling at previous inventory for all other types of subplots, this data will not be used (zeroed out) because this seedling is assumed to be accounted for in the previous inventory database.

If BREAST_HT_AGE = 0 then set HT = .5 (has not reached breast height yet)

if the BREAST_HT_AGE > 0 then set HT = 2.0

B. SAPLINGS AND YOUNG TREES: All species with an CURRENT INVENTORY BREAST_HT_AGE < 30 YEARS old OR with an CURRENT INVENTORY DBH >= 2.5 and < 12.5 cm D.B.H. -- All survey units:(note: PREVIOUS INVENTORY data are used for stumps and dead trees)

Calculate the annual height growth and then the missing height as follows:

AHG = (HT - 1.37)/BREAST_HT_AGE

where: AHG = annual height growth
HT = height at one of the occasions (meters)
BREAST_HT_AGE = breast high age at one of the occasions

Use data for the most recent occasion available. The AHG will then be used to estimate a projected height with the equations:

If HT3 is known, HP2 = HT3 - (AHG*REMSRT_PERIOD)
If HT2 is known, HP3 = HT2 + (AHG*REMSRT_PERIOD)

where: HT3 = height in meters at current inventory
HT2 = height in meters at previous inventory
HP = projected height (for a missing previous inventory or current inventory height)
REMSRT_PERIOD = remeasurement period--years between inventories.

Minimum estimated height
If HP2 is less than 1.5 meters, then set the height to 1.5 meters, for saplings.

C. TREES: with an CURRENT INVENTORY BREAST_HT_AGE >= 30 YEARS old and >= 12.5 cm DBH_MM.

The general model for height growth estimation follows:

When the height at OCC 2 is known: AHG=[(HA2/HE2) * (HE3 - HE2) * X / (RP)]

When the height at OCC 3 is known: AHG=[(HA3/HE3) * (HE3 - HE2) * X / (RP)]

Thus: HP3 = (HA2 + (AHG * RP))
HP=projected height
HP2 = (HA3 - (AHG * RP))
Where: AHG = annual height growth estimated from a known height
HA = actual known height
RP = Years between measurement occasions.
HE = height derived from site index equation.
X = a coefficient that varies by species and age, used to calibrate the HE heights and AHG.

Two of the variables in the general model above must be calculated: the coefficient 'x' and the estimated height 'HE'. The equations to calculate 'x' must be created at each occasion and for each survey unit, by analyzing data from the current inventory. HE equations are shown in the previous section. NOTE: These equations or factors will differ by survey unit.

To estimate a missing height, the Annual Height Growth (AHG) is calculated from one measured height, one estimated height for occasions 2 and 3 (using SI equations) and the remeasurement period. We do not use an estimated height from Site Index equations directly, because we found that an adjustment or calibration of the height (based on actual data from the location of the tree) provides a better estimate of the missing measurement. The coefficient 'x' shown below, provides the necessary calibration.

NORTH COAST
CONIFERS:

1. Douglas-fir (202): if BREAST_HT_AGE >= 30 AND < 100 years then x = 1.1428813

   if BREAST_HT_AGE >= 100 AND < 250 years then x = 2.0534373

   if BREAST_HT_AGE >= 250 AND < 350 years then x = 8.4526312

   if BREAST_HT_AGE >= 350 then x = 1.7651627

2. Redwood (211): if BREAST_HT_AGE >= 30 AND < 100 years then x = .9823969

   if BREAST_HT_AGE >= 100 AND < 250 years then x = 1.1628668

   if BREAST_HT_AGE >= 250 then x =23.4195790

3. Ponderosa pine (122): x = 1.22498

4. Sitka spruce (98): x = 1.4050012

5. Bishop pine (120): x = 1.4050012

6. All other Conifers: x = .8798

NORTH COAST
HARDWOODS--on timberland (not on Oak Woodland)

7. THERE IS NO EQUATION 7

8. Species 312, 351, 330,492,542,510,747,374: x = 1.0873181

9. Species 361, 431, and 631: x = 1.1227382

10. Species > 800: x = .7698584

CENTRAL COAST
CONIFERS:

1. Douglas-fir (202): if BREAST_HT_AGE >= 30 AND < 100 years then x = 1.193668

   if BREAST_HT_AGE >= 100 AND < 200 years then x = 2.276736

   if BREAST_HT_AGE >= 200 then x = 4.943352

2. Redwood (211): if BREAST_HT_AGE >= 30 AND < 300 years then x = 1.1415236

   if BREAST_HT_AGE >= 300 then x =23.4195790

3. All other Conifers: x = 1.0901193

HARDWOODS--on timberland (not on Oak Woodland)

4. Species 631: x = 1.200881

5. Species > 800 < 900, and 361: x = .921096

6. All other Hardwoods: x = 1.01492

NORTH INTERIOR AND SACRAMENTO UNITS

CONIFERS:

1. Douglas-fir (202): if BREAST_HT_AGE >= 30 AND < 150 years then x = 1.6253049
   and Redwood (211) if BREAST_HT_AGE >= 150 years then x = 3.8137014

2. All Pines, (103-127): if BREAST_HT_AGE >= 30 AND < 125 years then x = 1.1845564
   except 133: if BREAST_HT_AGE >= 125 then x = 2.9880311

3. True firs (< 23): if BREAST_HT_AGE >= 30 AND < 100 years then x = 1.0734492
   if BREAST_HT_AGE >= 100 then x = 1.5006024
4. Incense Cedar (81): if BREAST_HT_AGE >= 30 AND < 150 years then x = .8226147
   if BREAST_HT_AGE >= 150 then x = 2.5213439

5. All other Conifers : x = 1.0

HARDWOODS--on timberland (not on Oak Woodland)

6. Black oak (818) x = 1.0884635

7. Canyon live oak (805) x = .8835917

8. All other Hardwoods: x = 1.196695

SOUTHERN AND SAN JOAQUIN UNITS

CONIFERS:

1. Most Pines: (116,117,119,120,122)	if BREAST_HT_AGE >= 30 AND < 90 years then x = 1.1225091 if BREAST_HT_AGE >= 90 then x = 1.6391386
2. True firs (< 23):	if BREAST_HT_AGE >= 30 AND < 75 years then x = .9691583 if BREAST_HT_AGE >= 75 then x = 1.1869157
3. Incense Cedar (81):	if BREAST_HT_AGE >= 30 then x = .8282039
4. Juniper (64):	x = 1.0
5. All other Conifers:	x = 1.584707

HARDWOODS--on timberland (not on Oak Woodland)

6. All Hardwoods:	x = .8035195

ESTIMATING TREE HEIGHT WHEN NO MEASURED HEIGHT IS AVAILABLE

[For timberland plots only]

New, back-dated points in recent clearcuts may lack measured heights at either previous inventory or current inventory. When no field measured or estimated height is available at either occasion, tree heights will be calculated by using one of the equations that follow.

These equations are used only for DBH >= 12.5 cm (no age limit). Saplings with no height at any occasion will be flagged, and a height assigned on an independent basis.

Our normal procedure when determining heights on trees that have NO height at either occasion is to calculate HT3 with the equation above (for no heights). This height is then projected backward with the equation that estimates a height when one height is available.

Substitute DBH2 for DBH_MM when calculating HTCALC2.

If HTCALC < 2 meters then set HTCALC to 2 meters.

LN = natural log

NORTH COAST

1. Species 202: HTCALC3= exp(.4338 + .0038*(site index) + .6516*(LN(DBH_MM))

2. Species 211: HTCALC3= exp(-1.4675+ .4482*(LN(site index)) + .6905*(LN(DBH_MM))

3. All other conifers: HTCALC3= exp(.5728 + .6983*(LN(DBH_MM))

4. All Hardwoods on timberland: HTCALC3= exp(1.3545 + .4224*(LN(DBH_MM))

CENTRAL COAST

1. DOUGLAS-FIR (202):HTCALC3= exp(.84932023*(LN(DBH_MM)))

2. REDWOOD (211): HTCALC3= exp(.83925443*(LN(DBH_MM)))

3. OTHER CONIFERS: HTCALC3= exp(.84019094*(LN(DBH_MM)))

4. OAKS and MADRONE : HTCALC3= exp(.76012343*(LN(DBH_MM)))

5. TANOAK (631): HTCALC3= exp(.81610498*(LN(DBH_MM)))

6. OTHER HARDWOODS: HTCALC3= exp(.82374698*(LN(DBH_MM)))

NORTH INTERIOR AND SACRAMENTO UNITS

1. DOUGLAS-FIR (202): HTCALC3= exp(.84591216*(LN(DBH_MM)))

2. TRUE FIRS (<23): HTCALC3= exp(.82747037*(LN(DBH_MM)))

3. INCENSE CEDAR(81): HTCALC3= exp(.76294480*(LN(DBH_MM)))

4. PINES: HTCALC3= exp(.81933272*(LN(DBH_MM)))

5. OTHER CONIFERS: HTCALC3= exp(.62445014*(LN(DBH_MM)))

6. BLACK OAK (818): HTCALC3= exp(.78940630*(LN(DBH_MM)))

7. CANYON LIVE OAK(805): HTCALC3= exp(.75465198*(LN(DBH_MM)))

8. OTHER HARDWOODS: HTCALC3= exp(.81082177*(LN(DBH_MM)))

SOUTHERN AND SAN JOAQUIN UNITS

1. TRUE FIRS (<23): HTCALC3= exp(.82346222*(LN(DBH_MM)))

2. INCENSE CEDAR(81): HTCALC3= exp(.77162823*(LN(DBH_MM)))

3. PINES (101-133): HTCALC3= exp(.82192856*(LN(DBH_MM)))

4. OTHER CONIFERS (<300): HTCALC3= exp(.81887957*(LN(DBH_MM)))

5. ALL HARDWOODS (>300): HTCALC3= exp(.73377260*(LN(DBH_MM)))

FACTORS FOR ADJUSTING TREES WITH LOW HEIGHT GROWTH

Factors to be inserted here for NC and rest of CA.   ***Karen*

If the DBH grows less than 2 centimeters in the remeasurement period, then set the AHG as follows:

NORTH INTERIOR AND SACRAMENTO UNITS (2,3)

Softwoods <100 years BREAST_HT_AGE AHG = 0.14

Softwoods >= 100 years BREAST_HT_AGE AHG = 0.11

Hardwoods AHG = 0.16

CENTRAL COAST (4)

Softwoods <100 years BREAST_HT_AGE AHG = 0.23

Softwoods >= 100 years BREAST_HT_AGE AHG = 0.16

Hardwoods AHG = 0.17

SOUTHERN AND SAN JOAQUIN UNITS (5,6)

Softwoods <100 years BREAST_HT_AGE AHG = 0.11

Softwoods >= 100 years BREAST_HT_AGE AHG = 0.20

Hardwoods AHG = 0.10

NORTH COAST (1)

***Karen--values to be added for NC unit

EQUATIONS TO CHECK THE REASONABLENESS OF HEIGHT, DIAMETER AND, AGE RELATIONSHIPS

Height, diameter and age relationships should be checked for reasonableness against the data collected during the previous occasion. The following equations define the maximum height for a given diameter, the maximum height for a given age, the minimum height for a given diameter, the maximum dbh for a given crown class and age, and a reasonable growth for a given diameter and age.

These equations are specific to the various Resource Areas in California. Be sure to use the appropriate set for the Area data you are testing. There are three sets of equations: one set for the North Coast, one set for the North Interior and one set for the rest of California as a whole. Note that the North Interior has no Redwood species therefore there will not be a species group '4' for any of the equations.

General Parameters:

Diameters are in centimeters
Heights are in meters
Breast High Ages are in years

For some tree relationships, the data were divided into groups of species, with an equation created for each species group. Other relationships did not justify such a breakdown, in these cases there might be one equation for all species combined. Species are grouped and coded as follows:

Species Group (SG)	Group name	Species codes within group
1	True firs	4 to 22
2	Cedars	41, 42, 81, 242
3	Major pines	122, 116, 117
4	Redwood	211
5	Douglas fir	202
6	All other softwoods	rest of softwood codes
7	All hardwoods	codes > 300

Check for a maximum span between DBH2 and DBH_MM of 25cm. If the difference is greater than 25 cm, print a message for the crew to verify that its really true.

ALL SEEDLINGS: (< 2.5 cm dbh, recorded as a "1" in the data)

1. If the BREAST_HT_AGE = 0 then the MAXHT = 1.3m (can’t be taller than breast height)

2. If the BREAST_HT_AGE >= 1 then the MAXHT = 4.5m

3. If the BREAST_HT_AGE >= 1 then the MINIMUM HT= 1.5m (must be taller than breast height)

NORTH COAST
NOTE: All of the equations below are for trees >= 2.5 cm dbh as a lower limit.

Set maximum heights on SAPLINGS for species 98, 17, and 211 = 10 meters

EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN DIAMETER:

IF SPGROUP=1 AND DBH <=20 CM
MAXHEIGHT= (DBH*(.904151+.01717 *DBH))
IF SPGROUP=1 AND DBH > 20
MAXHEIGHT= (DBH*(1.403852-.00971 * DBH)) IF DBH > 45 MAXHT = 45m

IF SPGROUP=2
MAXHEIGHT= (DBH*(.723776+.003194* DBH)) IF DBH > 45 MAXHT = 39m

IF SPGROUP=3 ----note different form of this equation.
MAXHEIGHT= (14.619643+.370183* DBH) IF DBH > 130 MAXHT = 63m

IF SPGROUP=4
MAXHEIGHT= (DBH*(1.70898 -.009112* DBH)) IF DBH > 80 MAXHT = 85m

IF SPGROUP=5
MAXHEIGHT= (DBH*(2.405016-.017496* DBH)) IF DBH >=55 MAXHT = 80m

IF SPGROUP=6
MAXHEIGHT= (DBH*(1.456057-.012441* DBH)) IF DBH >=50 MAXHT = 42M

IF SPGROUP=7
MAXHEIGHT= 40 M

EQUATIONS TO ESTIMATE THE MINIMUM HEIGHT FOR A GIVEN DIAMETER.

IF DBH <=10 CM THEN THE MIN HEIGHT IS 1.5 METERS, for all species.

IF DBH > 10 CM THEN THE MIN HEIGHTS ARE AS FOLLOWS:

IF SPGROUP=1
MINHT = (5.733299 + .282316 * dbh) (turn off until further notice Oct 21,1993)

IF SPGROUP=2
MINHT= (-2.255748 + .674907 * dbh)

IF SPGROUP=3
MINHT= (5.004174 + .266788 * Dbh)

IF SPGROUP=4
MINHT= (1.771694 + .204274 * Dbh)

IF SPGROUP=5
MINHT= (2.72741 + .235093 * dbh)

IF SPGROUP=6
MINHT= (3.111472 + .272081 * dbh)

IF SPGROUP=7
MINHT= (3.560533 + .082294 * dbh)

NORTH COAST
EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN BREAST_HT_AGE.

IF BREAST_HT_AGE is less than 100 years:
MAXHT = (BREAST_HT_AGE * (2.265088 - .014672 * BREAST_HT_AGE))

IF BREAST_HT_AGE is greater than or equal to 100 years:
MAXHT = 85 meters.

EQUATIONS TO ESTIMATE THE MAXIMUM DIAMETER FOR A GIVEN AGE.
MAXDBH=centimeters
BREAST_HT_AGE=years

DO NOT check Redwoods for this relationship. There was no consistant relationship found that could be captured in an equation, therefore we will not check this species. All other species -- start this relationship check on trees > 20 years old. This equation did not perform well for the small age classes.

Crown classes 1, 2 and 3:
For trees > 20 years and < 300 years old:
MAXDBH = (BREAST_HT_AGE*(2.696821 - .007827 * BREAST_HT_AGE));

For trees >= 300 years:
MAXDBH = 200 cm

Crown class 4:
For trees > 20 years and < 200 years
MAXDBH = (BREAST_HT_AGE *(1.93692 - .007729 * BREAST_HT_AGE))

For trees >=200 years
MAXDBH = 120 cm

Crown class 5:
For trees > 20 years and < 250 years
MAXDBH = (BREAST_HT_AGE *(1.595317 - .004802 * BREAST_HT_AGE))

For trees >=250 years
MAXDBH = 145 cm

GROWTH/DIAMETER RELATIONSHIPS

The following factors estimate reasonable Growth/Diameter relationships, for the species groups:

Where: Annual squared diameter growth:
ASDG = (DBH_MM**2 - DBH2**2) / (YEARS IN REMEASUREMENT PERIOD)

Mean annual squared diameter growth:
MASDG = (DBH_MM**2/BREAST_HT_AGE)

Calculate above variables for incoming (occ 3) diameters and then calculate the following ratio:

Growth Ratio=ASDG/MASDG

NORTH COAST
GROWTH/DIAMETER RELATIONSHIPS

If this ratio is greater than the amount calculated below, the tree should be bored to check the age.
Acceptable Ratios:
For Species Group 1-3: IF Growthratio > 1.85 bore for age.
For Species Group 4: IF Growthratio > 6.50 bore for age.
For Species Group 5: IF Growthratio > 3.00 bore for age.
For Species Group 6: IF Growthratio > 1.25 bore for age.
For Species Group 7: IF Growthratio > 3.50 bore for age.

Check for bad ages with the following query:

If BREAST_HT_AGE < 12 and DBH > 10.0 cm then verify the age is correct.

This showed up as a problem when previous inventory reference trees became tally trees. Downloaded age was (age+remeasurement period), so these trees may have an age of 9-12 regardless of diameter.

NORTH INTERIOR
EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN DIAMTER:

IF SPGROUP=1 For diameters UPTO 90cm:
MAXHT=(DBH(1.12609 - .005821(DBH))) + 1.0>90cm MAXHT=55m

IF SPGROUP=2 For diameters UPTO 75cm:
MAXHT=(DBH(0.828687 - .003928(DBH))) +1.0>75cm MAXHT=45m

IF SPGROUP=3 For diameters UPTO 65cm:
MAXHT=(DBH(1.218223 - .00715 (DBH))) +1.0>65cm MAXHT=50m

IF SPGROUP=5 For diameters UPTO 65cm:
MAXHT=(DBH(1.386186 - .009526(DBH))) +1.0>65cm MAXHT=50m

IF SPGROUP=6 For diameters UPTO 50cm:
MAXHT=(DBH(0.967001 - .006555(DBH))) +1.0>50cm MAXHT=41m

IF SPGROUP=7 No satisfactory relationship could be developed for hardwoods, so the maximum height will be 35 meters.

THE FOLLOWING EQUATIONS PREDICT MAXIMUM DBH FOR A GIVEN BREAST_HT_AGE BY CROWN CLASS:

Crown class <= 3 MaxDbh= BREAST_HT_AGE(1.614312-.004183(BREAST_HT_AGE))

Crown class = 4 MaxDbh= BREAST_HT_AGE(.914645-.003392(BREAST_HT_AGE))

Crown class = 5 MaxDbh= BREAST_HT_AGE(.809544-.004948(BREAST_HT_AGE))

NORTH INTERIOR
FACTORS FOR ESTIMATING REASONABLE GROWTH/DIAMETER RELATIONSHIPS
Where: Annual squared diameter growth:

ASDG=(DBH_MM**2-DBH2**2)/(YEARS IN REMEASUREMENT PERIOD)

Mean annual squared diameter growth: MASDG = (DBH_MM**2/BREAST_HT_AGE)

Calculate above variables for incoming (occ 3) diameters and then calculate the following ratio:

GROWTHRATIO= ASDG/MASDG

Spgroup=1, 2, 5, 7 if GROWTHRATIO > 3.5 then the tree should be bored.
Spgroup=3 if GROWTHRATIO > 3 then the tree should be bored.
Spgroup=6 if GROWTHRATIO > 2 then the tree should be bored.

EQUATIONS FOR ESTIMATING THE MAXIMUM HEIGHT FOR A GIVEN AGE:

If AGE >= 12 years and < 100 years then:
MAXHT= (26.7762* NaturalLOG(AGE+8)) - 61.2236

If AGE >=100 years then:
MAXHT= (18.3263* NaturalLOG(AGE+8)) - 20.8788

EQUATIONS FOR ESTIMATING THE MINIMUM HEIGHT FOR A GIVEN DIAMETER:

If DBH <=6 cm then MINHEIGHT = 1.5

If DBH >6 and < 17.5 cm then: MINHEIGHT = DBH(.288076 - .002814(DBH))

If DBH >=17.5 cm then: MINHEIGHT = DBH(.064551 - .000609(DBH))

SOUTHERN HALF OF CALIFORNIA AND ALL OTHER SURVEY UNITS
(Survey Units: Central Coast, Sacramento, San Joaquin, Southern)

EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN DIAMETER.

When Species Group=1
MAXht= (dbh*(1.531166-.008549* dbh)) WHEN diam >= 50 then maxht = 55m

When Species Group=2
MAXht= (dbh*(.963552-.005089* dbh)) WHEN diam >= 66 then maxht = 42m

When Species Group=3
MAXht= (dbh*(1.173112-.004400*dbh)) WHEN diam >= 60 then maxht = 55m

When Species Group=4
MAXht= (dbh*(1.219288-.005051 *dbh)) WHEN diam >= 60 then maxht = 55m

SOUTHERN HALF OF CALIFORNIA AND ALL OTHER SURVEY UNITS
(Survey Units: Central Coast, Sacramento, San Joaquin, Southern)

EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN DIAMETER

When Species Group=5
MAXht= (dbh*(1.360242-.006162*dbh)) WHEN diam >= 60 then maxht = 60m

When Species Group=6
If Dbh < 5 cm then MAXHT = 5m
If diam >= 5 but less than 85 cm: MAXht= (dbh*(.985697-.004806*dbh))
If diam >= 85 then maxht = 50m

When Species Group=7
If Dbh <= 15 cm then MAXHT = 11m
If Dbh > 29 cm the MAXHT = 40m
otherwise:
MAXht= (dbh*(1.847655-.017008*dbh))

EQUATIONS TO ESTIMATE THE MINIMUM HEIGHT FOR A GIVEN DIAMETER.

When SPGROUP=1
If dbh < 12.5 then MINht = 1.5
else MINht = (-2.287491 + .308053* dbh)

When SPGROUP=2
If dbh < 10.0 then MINht = 1.5
else MINht = (-0.595540 + .25037 * dbh)

When SPGROUP=3
If dbh < 4.5 then MINht = 1.5
else MINht = (0.636023 + .19459 * dbh)

When SPGROUP=4 NOTE: MINht should never be < 1.5
MINht = (1.351154 + .30619 * dbh)

When SPGROUP=5
If dbh < 16.0 then MINht = 1.5
else MINht = (-3.837579 + .333431 * dbh)

When SPGROUP=6
If dbh < 6.0 then MINht = 1.5
else MINht = (.160437 + .227717 * dbh)

When SPGROUP=7
If dbh < 10.0 then MINht = 1.5
else MINht = (.727179 + .079457 * dbh)

SOUTHERN HALF OF CALIFORNIA AND ALL OTHER SURVEY UNITS
(Survey Units: Central Coast, Sacramento, San Joaquin, Southern)

FACTORS FOR ESTIMATING REASONABLE GROWTH/DIAMETER RELATIONSHIPS
Where: Annual squared diameter growth = ASDG

ASDG = (DBH_MM**2 - DBH2**2) / (YEARS IN REMEASUREMENT PERIOD)

Mean annual squared diameter growth =MASDG = (DBH_MM**2/BREAST_HT_AGE)

Calculate above variables for incoming (occ 3) diameters and then calculate the following ratio:

Growth Ratio=ASDG/MASDG

If this ratio is greater than a certain amount, the tree should be bored to check the age.
Acceptable Ratios:
For Species Group 1: IF Growthratio > 3.5 bore for age.
For Species Group 2: IF Growthratio > 4.5 bore for age.
For Species Group 3: IF Growthratio > 3.5 bore for age.
For Species Group 4: IF Growthratio > 1.5 bore for age.
For Species Group 5: IF Growthratio > 4.0 bore for age.
For Species Group 6: IF Growthratio > 2.25 bore for age.
For Species Group 7: IF Growthratio > 3.5 bore for age.

EQUATIONS TO ESTIMATE THE MAXIMUM DIAMETER FOR A GIVEN BREAST_HT_AGE.

maxdbh=centimeters
BREAST_HT_AGE=years

IF crown class=1-3
MAXDBH=(BREAST_HT_AGE*(2.710478 - .008076 * BREAST_HT_AGE))
If age >= 80 years then maxdbh = 165cm

IF crown class=4
MAXDBH=(BREAST_HT_AGE*(1.524269 - .005092 * BREAST_HT_AGE))
If age >= 50 years then maxdbh = 65cm

IF crown class=5
IF age is > 10 years and < 60 years:
MAXDBH=(BREAST_HT_AGE*(1.327851 - .009658 * BREAST_HT_AGE)) (dont check ages under 10 years)
If age >= 60 years then maxdbh = 45cm

EQUATIONS TO ESTIMATE THE MAXIMUM HEIGHT FOR A GIVEN BREAST_HT_AGE
SOFTWOODS--
< 75 YEARS MAX HT = BREAST_HT_AGE (1.458268 - .005435 (BREAST_HT_AGE))
>= 75 YEARS MAX HT = 70 METERS

HARDWOODS--
< 50 YEARS MAX HT = BREAST_HT_AGE (1.208503 - .006320 (BREAST_HT_AGE))
>= 50 YEARS MAX HT = 45 METERS

D. OAK WOODLANDS (GLC=44)
to estimate HEIGHTS on Oak Woodland plots in California.

For trees with DBH >= 12.5 cm, no age breakdown:
Species codes = 839,801,805,981

HTCALC = EXP (1.14909564 + .41443934*(LN(DBH)) - .03011536*CROWNRATIO)

Species codes = 807,811,815,818,821

HTCALC = EXP (.90970231 + .47125936*(LN(DBH)) - .03789066*CROWNRATIO)

Species codes = 312,330,352,361,730,920,999, and other hardwoods

HTCALC=EXP (.48561895 + .63299750*(LN (DBH)) - .03516625*CROWNRATIO)

Species codes < 300 and Species code= 510

HTCALC = EXP (1.49039392 + .51907709*(LN(DBH)) - .07521029*CROWNRATIO)

SAPLINGS--on Oak Woodland Plots:

For trees with DBH_MM >= 2.5 or DBH < 12.5 cm, no age breakdown:
Species code = 839,801,805,981
HTCALC=EXP (.594276   + .56085 * (LN(DBH)));

Species code = 807,811,815,818,821
HTCALC=EXP (.333469   + .597409 * (LN(DBH)));

Species code = 312,330,352,361,730,920,999, and other hardwoods
HTCALC=EXP (.461614   + .596453 * (LN(DBH)));

Species code < 300 OR Species code= 510
HTCALC=EXP (.008531 + .887623 * (LN(DBH)));

Where: LN(DBH) is the natural log of DBH in cm.
HTCALC is in meters.

PROCEDURE FOR OAK WOODLAND PLOTS WHEN ONE HEIGHT IS KNOWN:

Use the equations below to calculate an estimated height for BOTH Previous inventory and Current inventory. Calculate a calibrating factor by dividing the known height by the calculated height for the same occasion. Use this calibrating factor to adjust the calculated height for the occasion where a height is needed. Calculate Annual Height Growth and use this to estimate the missing height.

1. There must be diameters for both occasions on every tree (run DBH missing parts equations first if necessary).

2. Calculate a HT2CALC using DBH2 and a HT3CALC using DBH_MM, for each tree.

IF AHG2 < 0 then AHG2 = .01

IF HT2 is known THEN estimate HT3 as follows:

Factor = HT2 / HT2CALC
HT3ADJ = Factor * HT3CALC
AHG2 = (HT3ADJ - HT2) / PERIOD
HT3ESTIMATE = HT2 + (AHG2 * PERIOD)

IF AHG3 < 0 then AHG3 = .01

IF HT3 is known THEN estimate HT2 as follows:

Factor = HT3 / HT3CALC
HT2ADJ = Factor * HT2CALC
AHG3 = (HT3 - HT2ADJ) / PERIOD
HT2ESTIMATE = HT3 - (AHG3 * PERIOD)

Where: PERIOD = remeasurement period in years
HT = tree height in meters

If NO HEIGHT is available on Oak Woodland plots: Use HT2CALC or HT3CALC as the final height estimate.

CULL DEDUCTIONS

(a) Cull for rot--BOARD FOOT VOLUME is reduced for rot by an amount that varies by the cull indicator code as follows:

Species group	Cull code	Percent deduction
conifer	0	0 percent
conifer	1	20 percent
conifer	2	50 percent
conifer	3	99 percent
hardwood	0	0 percent
hardwood	1	20 percent
hardwood	2	50 percent
hardwood	3	99 percent

CUBIC FOOT VOLUME is reduced by a percent that is equal to the board-foot deduction in % and multiplied by (.00433*dbh), with dbh in centimeters.

(b) cull for form and missing parts--"conifer cull other" is recorded as a percent.

(c) Hidden cull--Hidden cull will be calculated for:

All conifers that are >100 years old (bh age) and >22.5cm in d.b.h., for redwood (211) >52.5cm in d.b.h.,and for incense cedar (81) of any age and >22.5 cm in d.b.h.

Exception--no hidden cull will be assigned to juniper (62-65), pinyon pine (133), yew (231), or torreya (251 = these will all be set to zero.

For red and white alder (351,352), aspen (746), black cottonwood, (747), Fremont poplar (748) and willow (920), hidden cull will be calculated on trees > 50 years B.H.age and > 27.5 cm in DBH .

For all other hardwoods, hidden cull will be calculated for all trees > 27.5 cm in DBH regardless of age.

Note: for poletimber trees (conifers <22.5, hardwoods <27.5) board foot cull deduction = 0

Hidden cull equations:

Note: Trees > 102.4 in d.b.h. will be given a hidden cull percent equal to that of a tree with a d.b.h. of 102.4 cm. EQUATION FORMS are as follows:

Board foot cull in percent = EXP(A + B * LN(DBH) + C * LN(DBH)**2)

Cubic foot cull in percent= (BOARD FOOT CULL %) * 0.00433 * DBH

Coefficients for Board Foot Equations

Equation number	Species	A	B	C
1	202 (Douglas-fir) 201 (bigcone Douglas-fir)	-3.798758	1.234194	0.0
2	108 (lodgepole pine), 101, 119 (whitebark pine) 122 (ponderosa pine) 103 (knobcone pine) 109 (Coulter pine) 116 (Jeffrey pine) 117 (sugar pine) 120 (Bishop pine) 124 (Monterey pine) 119 (western white pine) also for 102,104,113,127	-1.363151	0.577229	0.0
3	14 (Santa Lucia fir) 15 (white fir) 17 (grand fir) 19 (sub-alpine fir) 20 (California red fir) 21 (Shasta red fir) 22 (noble fir)	-16.134651	7.109226	-0.64695
4	263 (western hemlock) 264 (mountain hemlock) 92 (Brewer spruce) 93 (Engelmann spruce 98 (Sitka spruce)	-15.690824	6.669715	-0.605709
5	242 (western redcedar) 41, 42 (Port-Orford-cedar 81 (incense cedar) 50 (cypress) 212 (giant sequoia)	-14.144005	5.654774	-0.443595
6	300-999 (all hardwoods)	-13.215805	5.814058	-0.525099
7	211 (REDWOOD)			

Trees < 52.5 cm are not assigned hidden cull.

Trees >= 52.5 cm are assigned hidden cull with the following equation for board foot cull:

Board foot cull percent = 353.479/DBH - 1.1186

TREE CLASSIFICATIONS

Field classification

Field classification of growth impactor, crown ratio, and crown class are used in determining the tree class, management type, treatment opportunity class. Codes and brief descriptions follow:

1. Growth Impactor codes:
Growth impactor data are used in determining tree class and treatment opportunity. The following codes are valid:

Growth impactor	Code
bark beetles	11
defoliators	12
balsam wooly aphid	13
terminal feeders	14
spruce budworm	15
laminated root rot	21
Armillaria root rot	22
blackstain root disease	23
Annosus root disease	24
white pine blister rust	25
dwarf mistletoe	26
other disease and rot	27
fire	30
animals	40
weather	50
suppression	60
excessively deformed sapling	70
dead top, spike top, top out	72
forked top or multiple stem	73
deformed bole	74
needles/leaves abnormal	75
release	80
other natural damage	90

2. Crown ratio codes:

Crown ratio is the percent of a tree's total height that supports living crown. The total height includes dead, missing or broken tops. Low crown ratios are usually an indication of poor tree vigor. Crown ratio codes follow below:

Percent Crown Ratio	Code
1-10	1
11-20	2
21-30	3
31-40	4
41-50	5
51-60	6
61-70	7
71-80	8
81+	9

TREE CLASSIFICATIONS

3. Crown class codes:

Crown class describes a tree's competitive position in the stand; it indicates how well the tree is competing for light and identifies trees that are free to grow.

Crown Class	Code
Dominant or Open Grown	2
Codominant	3
Intermediate	4
Overtopped	5

Tree Classes
Growing Stock Code = 0 for classes 1&2, and = 1 for classes 4-6.

1. Sound cull a.) A tree of noncommercial species (62, 64, 65, 127, 133, 231, 341, 374, 492, 660, 920, 999).

   b.) A suppressed sapling. DBH < 12.5cm. (Growth impactor = 60)

   c.) A tree that will never produce a sawlog (Growth impactor = 70)

   d.) A conifer or a hardwood (species 351, 352, 747 or 510) tree with total cull between 76 and 99, not primarily due to rot. Includes hardwoods with form class 5.

2. Rotten cull--A tree that is > 75 percent defective, mainly due to rot.

3. Note that Tree class code = 3 does not exist in California.

4. High risk growing stock --Any tree that does not qualify as a sound or rotten cull but is likely to die either before reaching maturity or, if mature, within 10 years. (Growth impactor code is > 0 and NE 12-15 and NE 60 (if < 12.5 cm) and NE 71-75).

5. Immature growing stock (all ecoregions except 3)--Tree <22.5 cm or < 60 years BHA that does not qualify as a sound cull, a rotten cull, or a high risk growing stock (tree class NE 1-4).

5b. Immature growing stock (ecoregion 3)--Lodgepole pine(108) <60 years BHA or <22.5 cm, Ponderosa (122) or Jeffrey (116) pines <53 cm in d.b.h. or other species <90 years BHA that does not qualify as a sound cull, rotten cull or high risk growing stock. (Tree class NE 1-4)

6a. Mature growing stock (all ecoregions except 3)--Tree >60 years BHA and >22.5 cm that does not qualify as a sound cull, rotten cull, high risk or immature growing stock (TC NE 1-5).

6b. Mature growing stock (ecoregion 3.)Lodgepole pine(108) >60 years BHA and >22.5 cm, Ponderosa (122) or Jeffrey (116) pine >53 cm in d.b.h. or other species >90 years BHA that does not qualify as a sound cull, rotten cull, high risk or immature growing stock (TC NE 1-5).

STAND POSITION

Stand position is a tree classification variable that separates the currently manageable component of the stand from both remnants of a previous stand (residual overstory) and young understory trees (futurestand). The following stand positions will be identified:

(1) Mainstand--The stand that is currently available for management for timber production. Most trees are mainstand. All trees will be classed as mainstand unless they qualify for futurestand or residual overstory.

(3) Futurestand--futurestand trees are small trees, usually seedlings or saplings, growing in association with a much larger mainstand. They are trees that, if not destroyed during harvest, would qualify as advanced regeneration for the next crop.

(5) Residual Overstory--Scattered large trees left after logging or fire and growing in association with a mainstand of seedlings, saplings, or small poles. Residual overstory trees are usually unwanted leavings of logging and are typically broken topped, skinned-up, and of low vigor.

HOW TO CALCULATE STAND POSITION

a. For each condition class (CC) plot identify the subplots with the centers in the condition class. Use only this group of subplots to determine the pivot tree (i.e. use NCENT3 or NCENTC).

b. Identify the potential pivot trees--On each subplot identify the live tree with the largest DBH (must have a crown class of 1-3) . In case of a tie, use the oldest tree.

c. Identify the pivot tree. [A tree that characterizes the upper stand] Since each CC plot will not have every subplot with a center in the CC, different procedures are used based on the count of subplots with centers. For each CC plot with 5 or 4-subplots, the pivot tree is the third largest tree selected in step (b) above. On CC plots with 3-subplots or 2-subplots, the pivot tree is the second largest tree selected in step (b) above. On CC plots with only 1-subplot, the pivot tree is the largest tree selected in step (b) above.

EXCEPTION:
If the 50 percent or more of the subplots have no tally (and therefore have no trees available to be chosen as a pivot), then use the group of trees selected on the remaining subplots (from step b above) and choose the smallest tree as the pivot -- in case of a tie -- select the oldest. [i.e. there must be tally on at least 3/5ths, 3/4ths, 2/3rds, or 2/2 of the subplots before the largest tree is selected--if this is not the case, then the smallest tree will be used]

d. Once the pivot tree is determined for the condition class plot, use the procedures outlined in step (e) below to identify the stand position of every tally tree. Each tree will be either mainstand, future stand,or residual overstory and coded as shown on the top of this page.

STAND POSITION (continued)

e. Determine stand position.

(1) When the pivot tree diameter is > 20 cm and < 50 cm, then all trees < 12.5 cm are future stand (3).
(2) When the pivot tree diameter is > 50 cm, then all trees < 20 cm are future stand (3).
(3) When the pivot tree diameter is > 12.5 cm and <=20 cm, then all seedlings are future stand (3).
(4) When the pivot tree diameter is < 12.5 cm, then all trees > 20 cm are residual overstory (5).
(5) All other trees are mainstand (1).

f. Stand position at previous inventory (on subplots used for change analysis). If the pivot tree at previous inventory is also the pivot tree at current inventory, then,for all tally trees live at current inventory, the occasion2 stand position will equal the occasion3 stand position. For tally trees not live at current inventory, the previous inventory stand position will be calculated separately. If the pivot tree at previous inventory is a different tree than the pivot tree at current inventory, stand position will be calculated separately for previous inventory and for current inventory.

TIME OF SELECTION RULE
FOR CALCULATING TREES-PER-HECTARE AND BASAL AREA-PER-HECTARE

There is an important rule to remember when calculating both trees per hectare and basal area. Because of the compilation procedures associated with continuous forest inventories (where we return to permanent plots each time) there is a rule to follow to determine the occasion of the data used in certain calculations. THE RULE IS:

The "time of selection" is the occasion (or inventory cycle/time period) when a given tree was most recently selected as a live tree. An exception to this applies to snags and stumps recorded on C subplots. If a tree has a tree history of 7 or 8 on C subplots, then the time of selection is Current inventory, even though the tree was reconstructed as live at Previous inventory. Use data from this Occasion to calculate the trees-per-hectare (TPH) that the tree represents in the inventory. This TPH will remain constant for both occasions and is used in all calculations that require TPH. This 'time of selection' information is also needed to determine the appropriate BA per Hectare formula to use on trees in variable radius plots.

> For example, if a tree was tallied as live at Previous inventory and remeasured again as a live tree at Current inventory, then the TPH is calculated using Current inventory data -- it was most recently selected (or tallied) as a live tree at Current inventory.
>
> If a tree was tallied as live at Previous inventory and remeasured again as a mortality tree at Current inventory, then the TPH is calculated using Previous inventory data -- it was most recently selected (or tallied) as a live tree at Previous inventory.
>
> If a tree was tallied as live at Previous inventory and remeasured again as a stump at Occasion 3, then the TPH is calculated using Previous inventory data -- it was most recently selected (or tallied) as a live tree at Previous inventory.
>
> If a stump was recorded on a C subplot then the time of selection is Current inventory. If a plot was access denied (SK=5,6) then the time of selection is Previous inventory.

TREES PER HECTARE

Since we only sample a portion of the trees found on an inventory plot, each tree actually represents many trees on a per unit area basis (can be acres or hectares). During compilation each tree sampled is 'expanded' to the number of trees it represents per unit area (TPH or TPA, trees-per-hectare or trees-per-acre).

Different equations are used to calculate this expansion, and depends on the type of plot within which a tree was selected (3.3m fixed-radius plot, 17m fixed-radius plot, or the 7 BAF variable-radius plot). The equation also depends on the occasion chosen, according to the time-of-selection rules.

The number of subplots used in the equations mentioned above is the total number of subplots on the plot that are in the inventory area . For the current inventory processing, TOTSUB is used --this is the total number of subplots in the inventory area (excludes R, 0), regardless of condition class.

For the processing of the change inventory, NSUBC is used --this is the total number of subplots in condition class 1 on the plot (INcludes R, 0, EXcludes N subplots).

TPH or TPA are used to expand the individual estimates for a given tree, to the estimate-per-acre, or estimate-per-hectare that individual trees represent.

For example, the individual tree volume calculated for a tree (directly from the volume equations shown later in this document) is expanded as follows:

tree volume * TPA = tree volume-per-acre
total volume the tree represents on the plot = tree volume-per-acre * area expansion factor

Other items that are expanded include number of trees, growth, mortality or basal area. To get the number of trees the tree actually represents, simply multiply the TPA by the area expansion factor.

RECOMPILATION OF PREVIOUS INVENTORY:

When compiling the change inventory, a trees-per-hectare-expansion will be computed for the current inventory trees. This same TPH should be used for all previous inventory trees as well. Trees that are seedlings at CURRENT INVENTORY are assumed to be NOT present at previous inventory. Seedlings for the previous inventory change compilation will be retrieved from the previous inventory datafile.

COMPILATION NOTES -- For the Trees Per Hectare calculations. The variable name for unexpanded trees/hectare at the subplot level in the compilation programs is called TPHS. This means the TPH has not been divided by the number of subplots (TOTSUB in the current inventory, and NSUBC in the change inventory).

TOTSUB = the number of subplots on the plot that are in the current inventory, all subplots except R and 0.

NSUBC = the number of subplots on the plot that are in the change inventory, all condition class 1 subplots except N.

RECOMPILATION OF PREVIOUS INVENTORY: (continued)
The equations below are used to calculate Trees-per-Hectare for each individual tree.

A. Use the equations below for trees with a Time-of-Selection = Current inventory:

ALL LIVE TREES AT CURRENT INVENTORY ON NR, R, N and C SUBPLOTS; AND RECONSTRUCTED

STUMPS ON C SUBPLOTS (TH=8); AND SNAGS ON N OR C SUBPLOTS (TH=7):

1. Trees with an CURRENT INVENTORY DBH < 17.5cm (selected on 3.3m fixed radius plot):

   Trees/hectare = [10,000 / (pi * 3.3**2)] / (# of subplots)

2. Trees with an CURRENT INVENTORY DBH of > 17.5cm and < 90cm: (selected on a variable radius plot, with a BAF=7 m2/ha; :

   Trees/hectare = BAF / [(CURRENT INVENTORY tree basal area) * (# of subplots)]
   where: CURRENT INVENTORY tree basal area = [pi * (DBH_MM/ (2*100))2]

3. Trees with an CURRENT INVENTORY DBH > 90cm (selected on 17m fixed radius plot):

   Trees/hectare = [10,000 / (pi * 17.0**2)] / (# of subplots)

B. Use the equations below for trees with a Time-of-Selection = Previous inventory:

ALL TREES TALLIED LIVE AT PREVIOUS INVENTORY BUT DEAD AT CURRENT INVENTORY ON remeasured (R, NR) SUBPLOTS (TREE HISTORY 3, 5, 8=remeasured stumps only);

TREE HISTORY 3 AND 5 ON C SUBPLOTS; AND FOR SNAGS (TREE HISTORY 7) ON NR,R (remeasured) SUBPLOTS; and for all '0' subplots:

1. Trees with an PREVIOUS INVENTORY DBH < 17.5cm (selected on 3.3m fixed radius plot):

   Trees/hectare = [10,000 / (pi * 3.3**2)] / (# of subplots)

2. Trees with an PREVIOUS INVENTORY DBH of > 17.5cm and < 90cm (selected on a variable radius plot, with a BAF=7 m2/ha;) :

   Trees/hectare = BAF / [(PREVIOUS INVENTORY tree basal area) * (# of subplots)]

   where: PREVIOUS INVENTORY tree basal area = [pi * (DBH2/ (2*100))2]

3. Trees with an PREVIOUS INVENTORY DBH > 90cm (selected on 17m fixed radius plot):

   Trees/hectare = [10,000 / (pi * 17.0**2)] / (# of subplots)

   Note: If the tree is on an access denied plot (SK=5,6) see the next page.

RECOMPILATION OF PREVIOUS INVENTORY: (continued)
Special procedures are required to produce estimates of harvest and mortality on plots that we never have visited.

FOR ALL FORMULAS ABOVE:

Number of subplots = TOTSUB = total number of subplots in the inventory (usually 5).
Note: This is not the number of subplots in the condition class of the tree.

TPHS = TPH * TOTSUB [used when calculating stocking variables]

CALCULATE ADDITIONAL TREES-PER-HECTARE VARIABLES FOR TREE IN SAMPLE KIND 5 and 6 (projected) PLOTS FOR ALL PREVIOUS INVENTORY LIVE TREES

Each PREVIOUS INVENTORY live tree in a sample kind 5 or 6 condition class is adjusted for estimated harvest and mortality. This is done by partitioning the single tree record into 2 or 3 records. The TPH calculated for the tree is divided up into proportions that reflect an estimate of mortality and harvest for the tree on the access denied plot. The result is a tree record for a live tree, a record for a mortality tree, and a record for a harvested tree (on Sk=6 only).

The TPH to start with is calculated as follows:

1. Time of selection is always Previous inventory.

2. Use the TPH method 'B' on the previous page to calculate TPH for the tree.

To create the mortality partition: (on both sample kind 5 or 6 plots)

(1) Partition TPH and create "TPH dead since PREVIOUS INVENTORY" and "TPH still alive at PREVIOUS INVENTORY"

TPH dead since PREVIOUS INVENTORY = TPH * AMR * RP

where:

AMR = annual mortality rate, derived from the general sample of trees.
RP = number of years between PREVIOUS INVENTORY and CURRENT INVENTORY

Assign this "TPH dead since PREVIOUS INVENTORY" as the TPH on the mortality tree record. Use PREVIOUS INVENTORY dbh and height to compile PREVIOUS INVENTORY plot attributes and volumes for this mortality tree record. Tree history for this record is 5.

Then:

TPH still alive at CURRENT INVENTORY = TPH - (TPH dead since PREVIOUS INVENTORY)

To create the Harvest partition: (on sample kind 6 plots)

(2) Partition the "TPH still alive at CURRENT INVENTORY" to create "TPH harvested since PREVIOUS INVENTORY"only if HDISC < 1.0

TPH harvested since PREVIOUS INVENTORY = TPH still alive at CURRENT INVENTORY * HDISC

where:

HDISC = the harvest discount factor assigned to the plot

RECOMPILATION OF PREVIOUS INVENTORY: (continued)
Tree history on these records is 3 if DBH2 <12.5 cm; and TH=8 if DBH2 > 12.5 cm. Assign this "TPH harvested since PREVIOUS INVENTORY" to the harvested tree record. Grow the tree's PREVIOUS INVENTORY dbh and hgt to the date of harvest. Compile both the PREVIOUS INVENTORY and the "date of harvest" (CURRENT INVENTORY) plot attributes and volumes for this tree record.

Note: TH=8 trees have a TPH, and an Current inventory DBH and Ht, and a volume.
TH=3 trees have a TPH, but no DBH_MM or HT3, or volumes.

To create the TPH for the LIVE tree record:
(3) TPH live at CURRENT INVENTORY = TPH still live at CURRENT INVENTORY - TPH harvested since PREVIOUS INVENTORY

Assign this "TPH live at CURRENT INVENTORY" to the live tree record, grow its PREVIOUS INVENTORY dbh and hgt to CURRENT INVENTORY and compile PREVIOUS INVENTORY and CURRENT INVENTORY plot attributes and volumes for this live tree record. Tree history = 1.

BASAL AREA

The basal area of a tree is the cross-sectional area of the bole at the point where DBH is measured. Basal area is calculated in square meters, using the equations seen below:

Tree Basal Area = pi * r2 (where r=radius at DBH, in cm.)

= pi * (DBH/2)2 (since r= half of the diameter)

= pi * (DBH/(2*100))2 (division by 100 converts cm to m)

= basal area in square meters

Converting tree BA to BA-per-hectare

FIXED RADIUS PLOTS

The PRIME inventory program uses a 3.3m fixed radius plot to select trees less than 17.5 cm in DBH and a 17.0m fixed radius plot to select trees >= 90cm. The basal area in square meters per hectare for a tree sampled on one of these fixed radius plots is:

Basal Area per Hectare= tree basal area * trees per hectare

where: TPH is calculated using the time-of-selection rules.

VARIABLE RADIUS PLOTS

Trees with a DBH >= 17.5cm and < 90cm are selected with variable radius sampling, using a basal area factor (BAF) of 7 square meters/hectare (about 30.48 square feet/acre). At the occasion when the tree was most recently selected as a live tree, all trees tallied on a variable radius plot represent the same amount of basal area per unit area -- regardless of tree size (DBH). In other words, each tree tallied represents 7 square meters per hectare of basal area at DBH, for this occasion.

1. For the Occasion chosen with the time-of-selection rule:

BA per hectare = (BAF / # of subplots) where BAF = 7

2. For the Occasion before or after the occasion determined above:

BA per hectare = tree basal area * trees per hectare

For example, if a 20 cm tree has a time of selection of Current inventory, then the BA/HA for Current inventory is calculated with # 1 above; and the BA/HA for Previous inventory is calculated with # 2 above.

QUADRATIC MEAN DIAMETER

QMD = [(sum basal area per ha/sum trees per ha)/(Pi/40,000)]1/2

For all condition class plots, a hardwood QMD, conifer QMD, and a combined QMD will be calculated for each condition-class plot where such trees were tallied. Only conifer mainstand trees will be used to calculate the conifer QMD for the mainstand. Hardwood mainstand and hardwood residual overstory trees will be used to calculate the hardwood QMD. Conifer mainstand, hardwood mainstand, and hardwood residual overstory trees will all be used to calculate the combined QMD. Exclude trees with a growth impactor code of 60, and--for the mainstand--seedlings (d.b.h. = .1) unless the pivot tree is a seedling. When calculating the conifer mainstand QMD, don't include conifer saplings (dbh <12.5 cm) with a crown ratio of less than 4. If the pivot tree is 12.5 cm or greater, exclude trees with a crown class of 5 from the mainstand QMD.

If a tree was excluded from the QMD calculation at previous inventory because it was a suppressed tree, check the crown class code on trees >12.5 and the crown ratio code on trees < 12.5 measured at Current inventory. If the tree is not coded as suppressed at Current inventory, then dont exclude it at EITHER occasion. This will produce QMD's that are parallel between occasions.

Separate conifer, hardwood and total QMDs will be calculated for futurestand trees. Trees will not be deleted from the futurestand QMD calculation because of crown class, crown ratio, or pivot tree size.

STOCKING DISCUSSION

Stocking is relative density expressed as a percent of normal density. An estimate of the stocking contribution of each tree is needed to calculate forest type, stand age, stand size, management type, treatment opportunity, stage of development, and WLH.

Stocking equations are used to provide the initial estimate of stocking for a tree. This stocking estimate is then adjusted to account for the impact of a number of factors that influence the real stocking contribution of the tree. Stocking will also be expanded to the condition class plot level. Stocking may be proportioned among the subplots (if necessary) to insure that total stocking does not go beyond (100% weighted by the proportion of the subplot in the CC) on a given subplot.

The result of each stocking equation is a variable called TSTKS = Tree stocking estimate at the subplot level (i.e. not yet divided by the number of subplots).

Each stocking estimate (TSTKS) is adjusted for:

1. Social Position
2. Growing in a Clump
3. QMD and the associated mortality discount
4. Stockable Condition Factor (SCF)
5. Plant Stockability Factor (PSF)

To adjust: (tree stocking estimate) * (adjustment factor)

The adjusted stocking above will be 'Expanded' which means it is brought up to the condition class plot level by dividing by the proportion of the subplot in the condition class of the tree.

To expand: (adjusted tree stocking) / (proportion of the subplot in the CC)

The unexpanded adjusted stocking estimate is 'Proportioned' across the subplot, to insure that mainstand stocking (or future stand) is limited to 100% in the condition class area of the subplot. After the tree stocking is adjusted, there is a possibility that the sum of the mainstand (or futurestand) unexpanded stocking could exceed the amount of (100% * the proportion of the subplot in the condition class). Use NSUB3 for the subplot count variable for the current inventory, and NSUBC for the subplot count variable for the change inventory calculations.

If the sum of the adjusted unexpanded (MS or FS) stocking on the subplot is GREATER than (100 * the proportion of the subplot in the condition class),then:

To proportion: (do this separately for Mainstand and for Futurestand trees)
[(adjusted unexpanded tree stocking)/(sum of adj. unexpanded stocking on the subplot/(100*proportion in the CC))]/[total number of subplots, whole and partial, in the CC of the tree]

If the sum of the adjusted unexpanded (MS or FS) stocking on the subplot is LESS than (100 * the proportion of the subplot in the condition class), then the proportioned stocking is:

(adjusted unexpanded tree stocking) /(total number of subplots, whole and partial, in the CC of the tree)

STOCKING DISCUSSION (continued)

Six types of stocking estimates are calculated for a tree:

1. Unadjusted unexpanded unproportioned stocking (TSTKS, STK)
2. Adjusted unexpanded unproportioned stocking (ADJSTK)
3. Unadjusted expanded unproportioned stocking (STKX)
4. Adjusted expanded unproportioned stocking (ADJSTKX)
5. Unadjusted unexpanded proportioned stocking (STKP)
6. Adjusted unexpanded proportioned stocking (ADJSTKP)

Stocking Type	When to use the stocking
1	Intermediate variable to calculate #2, #3 and #5.
2	Intermediate variable to calculate #4 and #6.
3	Intermediate variable (not used).
4	Stand age, management type, treatment opportunity, stage of development also used to calculate #6.
5	Wildlife habitat analysis
6	Forest type, Stand Size

STOCKING EQUATIONS

Stocking is relative density expressed as a percent of normal density (TSTKS). Before TSTKS is used, it is adjusted for social position, clumps, QMD, PSF, and SCF. Stocking equations will vary by species and were extracted from the sources listed below.

Softwoods:

Species	Source	Equation
1. Douglas-fir (202) Big cone D.F. (201)	USDA Bull. 201	TSTKS=0.00073722*(DBH**1.54385)*TPHS
2. West. hemlock (263) mtn hemlock (264) true firs (11-22) spruces (92,93,98) cedars (41,42,81,242) cypress (50) Pacific yew (231) California torreya (251)	USDA Bull. 1273	TSTKS=0.00036526*(DBH**1.67)*TPHS
3. Redwood (211) Giant sequoia (212)	Empirical data	TSTKS=.00028275*(DBH**1.6757)*TPHS
4. Lodgepole pine (108) knobcone pine (103) whitebark pine (101)	Basic data from from PNW 8	TSTKS=0.00035001*(DBH**1.7)*TPHS
5. Ponderosa pine (122) sugar pine (117) Jeffrey pine (116) Coulter pine (109) Bishop pine (120) Monterey pine (124) Digger pine (127) Pinyon pine (133) Junipers (61-64)	Basic data from USDA Bull. 630	TSTKS=0.0003659*(DBH**1.73)*TPHS
6. W. white pine (119) Limber pine (113) Foxtail pine (104) Bristlecone pine (102)	Derived from USDA Bull. 323	TSTKS=0.00026889*(DBH**1.734)*TPHS

Hardwoods:

8. Red alder equation (use for all hard- woods except 312, oaks,746,542)	Derived from PNW Res. Paper No. 36.	TSTKS=0.00183402*(DBH**1.4057)*TPHS
9. Maple (312)	National list	TSTKS=0.0010742*(DBH**1.53)*TPHS
10. Ash (542)	National list	TSTKS=0.003101*(DBH**1.13)*TPHS

STOCKING EQUATIONS (continued)

Hardwoods:

Species	Source	Equation
11. Aspen (746)	National list	TSTKS=0.00157244*(DBH**1.39)*TPHS
12. Oaks (800-900)	National list	TSTKS=0.0009910*(DBH**1.63)*TPHS

Note: equations 9-12 are from similar species in other parts of the country. They are expected to be better equations than the default 'Alder' equation previously used for ALL hardwoods. (suggested by the National Stocking committee).

Where stocking equation variables are:

TSTKS = Percent Normality = the density contribution of an individual tree on a one-subplot plot.

DBH= Diameter breast high
TPHS=trees per hectare not yet divided by the # of subplots.

STOCKING ADJUSTMENTS

Adjustment for Social Position -- using Crown Ratio and Crown Class: The basic equations are assumed to describe the relationship between a tree's d.b.h., species, and its contribution to relative stand density. A tree's social position affects its density contribution -- for example, a dominant tree occupies more space than an overtopped tree of the same size and species.

Adjust the stocking by multiplying by the following:

Crown ratio code	DBH LT 12.5 cm	DBH GE 12.5 cm Crown class 2-3	Crown class 4	Crown class 5
GT 40 % (5+)	1.1	1.1	.7	.4
21-40 % (3-4)	.7	1.1	.7	.4
LE 20 % (1-2)	.4	.7	.7	.4

Adjustment for seedlings and saplings growing in a Clump--All hardwoods growing in a clump have been assigned a clump code of '1' in the field. Clumps are defined as 3 or more hardwood stems originating from one root system. The clump adjustment is used to adjust stocking estimates, because trees in clumps contribute less to stocking than individual trees. The clump adjustment is used to adjust stocking only on hardwood trees with a d.b.h. less than 12.5 cm.

Seedlings (<2.5cm) : Calculate stocking on all seedlings. If a seedling has a clump code=1, then divide the stocking in half and assign this adjusted stocking to the seedling.

Saplings (>=2.5 and < 12.5cm) : Calculate stocking on all saplings. If a sapling has a clump code=1, then adjust the stocking by dividing by the average number of stems per clump shown in the table below. This average was summarized from the Previous inventory data, by species and survey unit.

Adjusted stocking = (stocking / clump adjustment)
Average Number of Stems per Clump = Clump Adjustment

North Coast SPP	North Coast Clump Adj.	North Interior SPP	North Interior Clump Adj.	Central Coast SPP	Central Coast Clump Adj.	Sacramento	Sacramento Clump Adj.	San Joaquin and Southern SPP	San Joaquin and Southern Clump Adj.
312	1	352	3	330	1	312	1	330	2
330	1	361	2	361	3	330	2	746	1
351	1	492	6	431	5	352	1	801	3
361	3	631	1	510	1	361	1	805	2
431	3	805	2	631	1	492	1	807	2
631	2	807	3	801	2	600	1	811	1
747	2	815	1	981	6	731	4	818	3
805	2	818	1			805	2	839	2
818	1	839	4			807	1	981	3
839	2	312	2			818	1		
981	2					839	1		

This method of adjustment was used to get around a problem that was discovered after the completion of field work. The original intention was to identify the first stem in each clump and assign that stem full stocking--and give that stem a clump adjustment of '1'. All other members of that clump would receive a clump adjustment of '0' -- which actually zeros out the stocking for

STOCKING ADJUSTMENTS (continued)

those stems (stocking * clump adj.). The problem we discovered was that we did not record which clump each stem was growing in. Therefore we have no way of assigning stocking to just one member of a clump. To remedy this, the previous inventory data was accessed, and an analysis of all sapling clumps was conducted. At previous inventory, one line was entered for each clump, and the total number of stems per clump was recorded. A mean of the number of stems was calculated by species and survey unit, and will be used to adjust the full stocking value calculated for each sapling with a clump code = 1.

Adjustment for QMD--In stands where the QMD is less than 20 cm, the stocking must be further adjusted to reflect the expected stocking at the time that the stand reaches 20 cm.

1. Calculate, separately, the QMD of live conifer trees and live hardwoods.

2. If the appropriate QMD (conifer or hardwood) is less than 20 cm:

(a) Multiply the stocking (TSTKS) of each mainstand tree by the ratio:

R = [(d.b.h. + 20 - QMD) / (d.b.h.)] ** x

Where:

x = 1.55 when stocking equation 1 and 3 are used;
x = 1.68 when equations 2 or 4 are used;
x = 1.4 when equations 8-12 (all hardwoods) are used; and
x = 1.7 for all other equations.

(b) Multiply the result of (a) above by the mortality discount factor

MDF = (0.73 + 0.0128*QMD).

Future stand tree stocking is calculated in the same way, using the appropriate mainstand hardwood and mainstand conifer QMDs.

Compilation note: TRCALC program adjusts the stocking for social position and clump (i.e. STOCK = TSTKS * social discount * clump discount) The TRATT program further adjusts this stocking for QMD, SCF, PSF. [i.e. ADJSTK = (STOCK * QMDadj) / (SCF*PSF)]

STOCKABILITY DISCOUNTS

ADJUSTMENTS FOR STOCKABLE CONDITION FACTOR AND PLANT STOCKABILITY FACTOR

Stockability refers to the ability of forest land to be inhabited by trees. If 50% of a subplot is covered with large rock and boulders, then only half of the area is stockable by trees. Some land is too dry or infertile and has the capacity to grow fewer trees compared to forest land on other plots. We need to recognize and quantify these differences in stockability. Stockability 'Factors' are developed and then applied to individual tree stocking and site productivity (MAI) for timberland conditions.

There are 2 types of stockability discounts:

1. Stockable Condition Factor (SCF) (i.e. 1-nonstockable area)
2. Plant Stockability Factor (PSF) (calculated with equations)

Note that the plant stockability factor used to be called weighted discount factor or WDF. The name was changed to add clarity to the term. The field manual (since its already printed) will still refer to WDF instead of PSF.

The SCF refers to characteristics of the plot that permanently impair the plot from achieving full or normal tree stocking. Characteristics include running water, high water table, rockiness, soil compaction, mass soil movement, etc. The nonstockable area is mapped on each subplot, but the amount found within each condition class was not recorded. Since we need to know this information on forest land, the map on each subplot must be examined where more than 1forest land condition exists. The nonstockable area should be assigned to one condition class, or be proportioned between condition classes if the map indicates it enters more than one CC on the subplot. These assignments are given to the compilation staff, and the data are coded into the appropriate program.

The PSF refers to the ability of the forest land area to grow trees based on certain plant indicators found on the plot. Equations have been developed that use this data and other variables to estimate the stockability of the area relative to the stocking found in normal yield tables. Not all forest land can grow the number of trees shown in these tables. A factor is developed and applied as a discount to tree stocking and MAI variables on each condition class plot.

Discounts to individual tree stocking PSF --The stocking of each conifer tally tree will be divided by the PSF discount calculated by the equations below. The stocking of each hardwood tally tree will be divided by a pre-set discount of PSF = 1.0.

SCF --The stocking of each tree on each subplot will be divided by the SCF discount on the subplot for the condition class of the tree. The SCF is the proportion of stockable area on the subplot.

SCF = (1 - proportion of nonstockable area)

STOCKABILITY DISCOUNTS FOR SITE PRODUCTIVITY, MEAN ANNUAL INCREMENT

In general, all stockability discounts for productivity should be handled as they were in Eastern Washington. That is, the discount factors(PSF,SCF) should be applied to the MAI instead of the plot area.

Please refer to a second document that provides details of the MAI calculation and application of the discounts. In general, one MAI is calculated on a plot and one PSF is calculated (a second PSF is possible but rare, when 2 ecological conditions exist on one plot).

First, the MAI is discounted by multiplying by the PSF. Since there is a SCF for each subplot and condition class, the second discount occurs on a subplot by subplot basis. For each subplot with timberland conditions, the discounted MAI from step 1 is multplied by the SCF on that subplot. The group of discounted MAI's that result, are averaged to produce a single mean MAI for the condition class plot.

CALCULATING THE PLANT STOCKABILITY FACTOR

[The PSF used to be called the weighted discount factor or WDF].

Plant stockability is determined one of three ways-- calculated with equations, set equal to 1.0 when no stocking problems exist, or set arbitrarily by plot.

There are no PSF equations for the North Coast survey unit, Central Coast unit, Southern unit, Mono and Alpine counties in the San Joaquin unit, and all other counties that have no timberland in our inventory (ONF). For all these areas--the PSF is set by hand and should be retrieved from the Previous inventory resource file. For many of these plots, the PSF is set to "1.0" but other plots were assigned a specific value after being reviewed by Analysts at previous occasions. We will retain all of the previous inventory PSF's for plots that are in counties with no equation developed for that county. In the North Coast, the PSF is always set to "1.0" on all plots.

Equations, based on plant and physiographic variables, are available for estimating stockability discounts in other counties and survey units in the state. At PREVIOUS INVENTORY, a stockability discount was calculated or set for every timberland plot. All plant variables and PSF (WDF) values used at PREVIOUS INVENTORY relate to the condition class present at subplot 1 center of the 5-point plot. We expect that the PSF at PREVIOUS INVENTORY will be the same or very close to the new PSF calculated at CURRENT INVENTORY. Differences may occur due to new species being added to the indicator list (inadvertently left off at PREVIOUS INVENTORY) and a few minor errors discovered in the equations used at PREVIOUS INVENTORY. At Current inventory, a PSF will be calculated for timberland conditions on the plot and used to adjust the estimate of MAI for that timberland. Most of the time one PSF will represent the stockability of all timberland on a plot. Occasionally, at CURRENT INVENTORY, the plot may cross over into another timberland condition class which has a significantly different stocking limitation. In this case, new plants will be identified on a second plant indicator list, and a second plant stockability factor calculated for the plot. A maximum of two PSF's are allowed on a plot.

If a PSF has been assigned at a previous occasion to a plot where an equation is available, check to see if new plants are now on the plant indicator list. If so, recalculate the PSF at CURRENT INVENTORY and be sure the previously hand-set PSF at PREVIOUS INVENTORY is still appropriate.

The state is divided into ecological units with a different equation (or no equation) for each. Plant variables (X1-X99) are given a value of 1 if the plant is present on the site and 0 if it is absent. Other variables in the equations include measured items such as elevation, precipitation and Dunnings Site index. Note: the Normal Stand Density Index (NSDI) variable in the equations below is described on page 65.

The PSF should always be calculated on timberland conditions, regardless if there are plants present on the plant indicator list. If no plants exist, the other variables in the equation will produce a PSF estimate for the plot.

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 1--Shasta and Trinity Counties

Plant Stockability Factor (PSF) = [-2 - 47(X1) - 84(X2) + 62(X3) + 99(X4) + 39(X5) + 92(X6) + 64(X7) + 33(X8) + 61(X9) + 32(X10) - 44(X11) + 0.00007739(X12) + 0.00001476(X13) - 0.000000009(X14)] / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = CECU-2, CEBE-2, OR CELE-3
X2 = CEOC OR CELE-1
X3 = QUGA-2, QUGAB, OR QUWI
X4 = ABMA-2
X5 = PILA OR PSME
X6 = CASE-3 OR PREM
X7 = QUKE
X8 = PYPI, TRLA-3, OR ASA
X9 = CHUMO, PTAN, OR SMI-1
X10 = PIPO
X11 = CEPR
X12 = ELEVATION (IN METERS SQUARED)
X13 = DUNNINGS SITE (feet**2) * ELEVATION meters
X14 = DUNNINGS SITE (feet**2) * ELEVATION meters**2

****NOTE: ABMA-2 WAS MISTAKENLY LEFT OFF OF THE PLANT LIST AT PREVIOUS INVENTORY AND THEREFORE NOT COLLECTED AS AN INDICATOR AT PREVIOUS INVENTORY. IT IS A VALID SPECIES FOR THE CURRENT CURRENT INVENTORY INVENTORY****

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 2-- Western Tehama, Glenn, Colusa, Sutter, Lake, Napa, and Yolo counties

PSF = [358 + 209(X1) - 44(X2) - 37(X3) + 49(X4) - 98(X5) -114(X6) - 82(X7) - 55(X8)] / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = STAND BASAL AREA per unit area >50 PERCENT TRUE FIR
X2 = SOIL DEPTH < 45.7 CM
X3 = ARCA-5
X4 = ROGY
X5 = PHSPO
X6 = ARMA-3 OR ARVI-3
X7 = CECO-2 OR CEIN-3
X8 = PISA-2, QUGA-2, QUGAB OR QUDU-2

****NOTE: CEIN-3 WAS MISTAKENLY LEFT OFF OF THE PLANT LIST AT PREVIOUS INVENTORY AND THEREFORE NOT COLLECTED AS AN INDICATOR AT PREVIOUS INVENTORY. IT IS A VALID SPECIES FOR THE CURRENT CURRENT INVENTORY INVENTORY****

****NOTE: QUDU-2 WAS CODED AS QUDU-1 AT PREVIOUS INVENTORY****

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 3-- Modoc, Lassen-county except the southwest portion (see Eco Unit 6), eastern Plumas, Eastern Sierra, eastern Nevada, eastern Placer, and eastern Eldorado counties.

PSF = [318 - 55(X1) + 74(X2) - 47(X3) + 86(X4) - 44(X5) - 61(X6) + 42(X7) + 63(X8) - 59(X9) - 99(X10) - 44(X11) - 77(X12) - 115(X13) - 35(X14)] / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = SOIL DEPTH < 45.7 CM
X2 = ABMA-2
X3 = CELE-3 OR CEBE-2
X4 = SYM-3
X5 = RICE, RIRO OR RIIN-2 (RIIN-2 was missed at CURRENT INVENTORY)
X6 = BRTE OR STI-1
X7 = ACLA-2
X8 = OSCH, SMI-1, CHUMO, PTAN, PYPI OR PYPIA
X9 = ERPE-3 OR ERCA-3 (SHOULD BE ADDED TO 91 PLANT GUIDE)
X10 = LONU-1 OR LOPL
X11 = BAL
X12 = POT-2
X13 = CAUM-2, LICI, OR LINU-2
X14 = AGHE, OR AGRE-2

****NOTE: ERYSIMUM PERENNE (ERPE-2) AND E. CAPITATUM (ERCA-3) WERE MISTAKENLY LEFT OFF OF THE PLANT LIST AT PREVIOUS INVENTORY AND THEREFORE NOT COLLECTED AS AN INDICATOR AT PREVIOUS INVENTORY. THEY ARE VALID SPECIES FOR THE CURRENT CURRENT INVENTORY INVENTORY****

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 4-- Western Sierra, western Nevada, Yuba, western Placer, and western Eldorado counties.

PSF = [171 + (X1) - 142(X2) - 54(X3) - 105(X4) - 109(X5) + 127(X6) - 153(X7) + 99(X8) - 109(X9) + 0.0005118(X10)] / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = UTM NORTH IN 1000 M MINUS 4200
X2 = SOIL DEPTH < 45.7 CM
X3 = ARVI-3
X4 = CECU-2
X5 = RULE
X6 = GOOB
X7 = POCO-6
X8 = VILO
X9 = SIHY
X10 = (DUNNINGS SITE INDEX--IN FEET)(ELEVATION--IN METERS)

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 5-- Amador, Calaveras, Tuolumne, Mariposa, and Kern. Eastern portions of Madera, Fresno, and Tulare counties.

PSF = [328 + 267(X1) - 112(X2) + 92(X3) + 161(X4) + 194(X5) - 91(X6)] /NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = PIMO-3
X2 = UMCA, QUDO, QUGAS, CECU-2, CEBE-2, CELE-3, RHCRI, CHR-8, GAFR, or PISA-2
X3 = PTAN
X4 = CHME-2, CHUMO, PYPI, PYPIA, ADBI, GOOB, VILO, DIS-3, or SMI-1
X5 = PESE-3
X6 = SIHY

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 6-- Eastern Tehama, Butte, western Plumas, southwestern Lassen counties. (see note below)

PSF = [-244.713 + 20.0899(X1) + 67.8407(X2) + 145.5649(X3) + 34.9109(X4) +
39.2050(X5) + 37.4798(X6) - 47.9219(X7) + 50.7120(X8) - 51.6700(X9) -
84.0552(X10) - 53.9562(X11) + 0.75176(X12) + 0.0116262(X13)
0.000007242(X14) - 0.0002654(X15)] / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = Any conifer present other than true fir
X2 = ABGR, ABMA-2 or ABMAS, ABPR, ABCO (any true fir)
X3 = ABMA-2 or ABMAS
X4 = ABCO PRESENT, and (ABMA-2 or ABMAS) ABSENT
X5 = PYPI
X6 = PYPIA OR CHUMO
X7 = CEPR
X8 = QUGA-2
X9 = PRSU-2
X10 = CECU-2, CELE-1, CEBE-2, CELE-3, OR CEOC
X11 = BRTE
X12 = ELEVATION in meters
X13 = (DUNNING SITE IN FEET**2)
X14 = (DUNNINGS SITE**2)(ELEVATION in meters)
X15 = (ELEVATION**2, in square meters)

Note that this equation for Ecological Unit 6 has changed slightly as of October 1993--compared to the field manual and older versions of the complete documentation. The variable 'X1' above was left out of the earlier versions. Coefficients were documented incorrectly--this new equation reflects all updates, and will be used for data processing. The results of this change mean that a new item is added to the plant indicator list for this ecological unit. The field crew did not collect data for the new 'X1' above, so the datafiles were searched for the answer to the question of presence or absence for this variable.

CALCULATING THE PLANT STOCKABILITY FACTOR

Ecological unit 7--Siskiyou county.

PSF = [355.82 + 80.99(X1) + 0.0043865(X2) - 79.83(X3) - 71.49(X4) - 52.56(X5) -
245.80(X6) - 79.90(X7) - 131.13(X8) - 75.63(X9) + 83.64(X10) - 97.79(X11) -
64.07(X12) - 118.22(X13) - 53.54(X14) / NSDI

OR if PSF is >0.8, set PSF = 1.0

Where: X1 = ABMA-2, ABMAS, ADBI, OR SMI-1
X2 = ANNUAL PRECIPITATION IN SQUARE CENTIMETERS
X3 = CHR-8
X4 = QUGA-2
X5 = FES-1
X6 = PICO-1 WHEN TOPO POSITION = 7
X7 = AGR-1 OR AGSP
X8 = LONU-1
X9 = ARVI-3
X10 = SAL13 WHEN TOPO POSITION NE 9
X11 = CAAP
X12 = JUOC
X13 = RHTR
X14 = ARTR

CALCULATING THE PLANT STOCKABILITY FACTOR

COUNTIES AND SURVEY UNITS WITH NO PLANT STOCKABILITY EQUATION:

Ecological unit 8-- Del Norte, Humboldt, Mendocino, Sonoma, Marin, Contra Costa, Alameda, Santa Clara, San Mateo, Santa Cruz, Monterey, Solano, San Benito, San Luis Obispo, Santa Barbara, Ventura counties. (i.e. ALL of North Coast and Central Coast counties)

'Ecological unit 9'--Other Areas with No equations--includes San Joaquin, Stanislaus, Merced, Kings, Alpine, Mono counties, and all counties in the Southern survey unit.

There are no stockability equations or guides for the two groups of counties listed above. Where stockability problems exist in these areas, the PSF discount factor has been set by hand and is on the PREVIOUS INVENTORY resource file. Unless changed by memo, the same discounts should be used for CURRENT INVENTORY.

The equations used in units 1-5 are published in PNW Research Note PNW-233, and the unit 7 equation is published in Research Note PNW-435. Equations in both of these publications were developed in English units, and have been converted to accept incoming metric data. The coefficients for elevation and precipitation were modified to convert metric data back to english units--elevation was converted from meters to 100's of feet, and precipitation was converted from centimeters to inches. This is mentioned to explain the differences in the equations between the published reports and this document. The equation for unit 6 is on file in a memo to M.E. Metcalf dated 1/21/72 and revised 3/15/72. A copy is included in an office report titled "Stockability-Productivity Survey: California, 1970-1972. The appropriate ecological unit for each plot is recorded on the CURRENT INVENTORY plot record. The indicators were entered at previous inventory and will be down-loaded to the Husky. In units 1-7, discounts will be recalculated from plant indicator records and other variables. In other areas, the PSF from PREVIOUS INVENTORY will be downloaded. In most cases the discount in area 8 will be 1.0.

NORMAL STAND DENSITY INDEX

Normal yield tables describe the stocking capacity of a stand and can be expressed as a Normal Stand Density Index (NSDI). Before the plant stockability factor (PSF) equations can be used a normal yield table appropriate for the site and species must be chosen. The NSDI indexes used in California should be chosen from the list below which becomes a variable in the PSF equation.

Site species code	NSDI
202	370
122, 116	365
108, 119	460
15	479
20, 21	600
109	365
17	370
98, 263, 264	400
Mixed Conifer	479
All other species	400

AGGREGATING SUBPLOT STOCKING TO DETERMINE HOW TO PROPORTION STOCKING:

The following table is used as a reference for those subplots that exceed 100% stocking. Adjusted, unexpanded, unproportioned tree stocking is summed at the subplot level by tree class, by stand position, and by hardwoods and conifers. The following table shows the summary that is made. The percent density is calculated for each cell in the table by summing the stocking in each category displayed below.

Stand position	Species group	cull	high risk	immature G.S.	mature G.S.	total
		--------------------percent density----------------------				
residual	conifer --	--	--	--	--	
overstory	hardwood	--	--	--	--	--
mainstand	conifer	--	--	--	--	--
mainstand	hardwood	--	--	--	--	--
futurestand	conifer --	--	--	--	--	
futurestand	hardwood	--	--	--	--	--

Developing proportioned stocking at the condition class plot level:

The tree stocking table shown above is produced for all subplots on the condition class plot. The goal is to have mainstand adjusted unexpanded stocking on any given subplot limited to 100 percent weighted by the size of the condition class. When this mainstand stocking exceeds that amount, the stocking of each mainstand tree will be reduced proportionately so that the mainstand adjusted unexpanded stocking will total 100 percent on the subplot. Future stand stocking will be proportioned in the same manner.

The adjusted, unexpanded, proportioned tree stocking is calculated by dividing the unproportioned, adjusted, unexpanded tree stocking by the total number of subplots (NSUB3, NSUBC). (see page 55 for all formulas) Unadjusted, unexpanded, proportioned tree stocking is calculated in the same manner.

FOREST TYPE

Each condition class plot will be assigned a "primary forest type." A "secondary forest type" will also be assigned if the plot is a mixture of conifers and hardwoods. Note: forest type codes are the same as species codes. [Use adjusted unexpanded proportioned stocking; and NSUB3]

Determine the relative proportions of live mainstand stocking of conifers and hardwoods, on each condition class plot. This includes trees with a Tree History of 1, 2, 4, 6 and trees with a stand position = 1 (mainstand).

Cull Trees are included in the stocking sums for forest type. In the procedure below, all references to 'stocking' refer to adjusted proportioned stocking of live mainstand trees.

Plurality is defined as the largest number in a group. For example, after the stocking is summed up by species, the species with the largest value holds the plurality.

FOREST TYPE CLASSIFICATION PROCEDURE

1. If the total stocking (hardwood and softwood combined) is less than 10, the stand on the plot is not stocked -- Forest Type = 99 = Nonstocked. Set Stand Age=99, Stand Size=6, Management Type=4, Stage of Development = 0.

2. If total hardwood stocking is greater than total conifer stocking, the forest type is the hardwood species with the plurality of hardwood stocking.

3. If total conifer stocking is greater than or equal to the total hardwood stocking, the forest type will be the conifer species with the plurality of conifer stocking, OR 'Mixed Conifer' as determined in step 5 below.

4. Determine if the stand is pure conifer, pure hardwood, or a conifer/hardwood mixture--if the stand is a mixture, assign a secondary forest type.

   A. If conifer stocking is GE 70% of total stocking on the plot, the plot is considered pure conifer--assign a Primary Forest Type based on the conifer species with the plurality of conifer stocking;No secondary type is assigned.

   B. If conifer stocking is LE 30% of total stocking on the plot, the plot is considered pure hardwood--assign a Primary Forest Type based on the hardwood species with the plurality of hardwood stocking; No secondary type is assigned.

   C. If conifer stocking is GE 31% and LE 69% of total stocking on the plot, the plot is a conifer-hardwood mixture. If conifer stocking is GE hardwood stocking, assign a Primary Forest Type based in the conifer species that has a plurality of conifer stocking, and assign a Secondary Forest Type based on the hardwood species that has a plurality of the hardwood stocking. If conifer stocking is LT hardwood stocking, assign a Primary Forest Type based on the hardwood species with a plurality of hardwood stocking, and assign a Secondary Forest Type based on the conifer species with a plurality of the conifer stocking.

FOREST TYPE CLASSIFICATION PROCEDURE (continued)

5. If the forest type is a conifer type, AND the conifer species is one of the following 8 species: Sugar pine (117), Incense cedar (81), Douglas-fir (202), Ponderosa pine (122) Jeffrey pine (116), White fir (15), Red fir (20), or Shasta red fir (21) the plot must pass through a 2nd algorithm to determine if it is Mixed Conifer.

MIXED CONIFER FOREST TYPE ALGORITHM:

** At this point, the Conifer Forest Type has been determined from species plurality.

1. If the forest type is Douglas-fir, AND the plot is in one of the 9 counties: Del Norte, (015), Humboldt (023), Marin (041), Mendocino (045), Napa (055), San Mateo (081), Santa Clara (085), Santa Cruz (087) or Sonoma (097)
   Then the conifer type is Douglas-fir.
   In any other county, change the forest type to mixed conifer -- FT =299.

2. If the forest type is Sugar pine (117), change the forest type to Mixed Conifer -- FT =299.

3. If the forest type is Incense cedar (081), change the forest type to Mixed Conifer -- FT =299.

4. If the forest type is Ponderosa or Jeffrey pine:
   If the stocking of Ponderosa pine (122) or Jeffrey pine (116), either singly or in combination, is greater than or equal to 80% of the total conifer stocking on the plot, then the forest type is Ponderosa or Jeffrey pine, whichever has the plurality.

   Otherwise, if the combined stocking of these 2 species is less than 80%, the forest type is Mixed Conifer -- FT =299.

5. If the forest type is white, red, or Shasta red fir:
   If the stocking of white fir (15), red fir (20), or Shasta red fir (21), either singly or in combination, is greater than or equal to 80% of the total conifer stocking on the plot, then the forest type is white fir, red fir, or Shasta red fir, whichever has the plurality.

   Otherwise, if the combined stocking of these 3 species is less than 80%, the forest type is Mixed Conifer -- FT =299.

STAND SIZE CLASS

Stand size class is determined from the adjusted unexpanded proportioned live mainstand stocking in trees (live trees, including culls) in various size classes. Use NSUB3 for the subplot count. Tree size classes are as follows:

Size-class	Description
Seedling or sapling	DBH <12.5 cm
Poletimber (conifer)	DBH >12.5 cm <22.5 cm
Poletimber (hardwood)	DBH >12.5 cm <27.5 cm
Small sawtimber (conifer)	DBH >22.5 cm <52.5 cm
Small sawtimber (hardwood)	DBH >27.5 cm <52.5 cm
Large sawtimber	DBH >52.5 cm.

Code	Stand-size class	Description
1	seedlings and saplings	50 percent or more of mainstand stocking is in seedling or sapling trees (trees < 12.5 cm).
2	poletimber	50 percent or more of mainstand stocking is in trees > 12.5 cm and mainstand stocking of poletimber trees exceeds mainstand stocking of sawtimber trees.
3	small sawtimber	50 percent or more of mainstand stocking is in trees > 12.5 cm, sawtimber stocking equals or exceeds poletimber stocking, and small sawtimber stocking exceeds large sawtimber stocking.
4	large sawtimber	50 percent or more of mainstand stocking is in trees >12.5 cm, sawtimber stocking equals or exceeds poletimber stocking, and large sawtimber stocking equals or exceeds small sawtimber stocking.
6	nonstocked	When the Primary Forest Type = 99.

MANAGEMENT TYPE ELEMENTS

Management type elements are composed of two items--management type and stage of development.

CODES FOR THE MANAGEMENT TYPE ELEMENTS

Management Type	Code	Stage of Development	Code
Conifer	1	Mature	3
Hardwood	2	Intermediate	2
Mixed stand	3	Regeneration	1
No manageable stand	4	Stand not present	0

GENERAL DEFINITIONS

a. Management Type

(1) Conifer stands--To qualify as conifer stands, three out of 5 subplots must have a stocking >= 25.

(2) Hardwood stands--Stands that do not qualify as conifer stands but have a stocking value of at least 25 for mainstand growing stock hardwoods on each of 3 out of 5 subplots-- qualify as hardwood stands.

(3) Mixed conifer-hardwood stands--Stands which fail to qualify as either conifer or hardwood stands but have 25 percent stocking of both groups combined on 3/5ths of the subplots.

(4) Management stand absent--Stands failing to qualify as conifer, hardwood, mixed conifer-hardwood, will be classified as management stand absent. Always code this for Forest Type = 99.

b. Stage of Development

(0) No stand present--Inadequate stocking of all live trees for regeneration, intermediate or mature stand. Always code for Forest Type = 99.

(1) Regeneration stands--Stands with a QMD of LT 20 cm.

(2) Intermediate stands--Stands with a QMD of GE 20 and LT 52.5 cm, and with the majority of trees in Tree Class 5.

(3) Mature stands--Stands with a QMD of GE 52.5 cm or stands that have the majority of trees in Tree Class 6.

KEY TO MANAGEMENT TYPES

[NOTE--Use adjusted expanded unproportioned stocking and NCENT3. Include only trees from subplots whose center is in the condition class.]

I. Conifer and hardwood mainstand growing stock(GS) stocking is GE 25 on 3/5ths of the subplots or have an average GE 20 over the entire plot.

A. High risk(Tree Class 4) and mature(Tree Class 6) conifer tree stocking is 50 percent or more of the conifer mainstand, and conifer mainstandstocking is greater than hardwood mainstand stocking. <u>MATURE CONIFER</u>

B. High risk and mature conifer stocking is LT 50 percent of the conifer mainstand.

1. Conifer mainstand GS stocking GE 25 percent on 3/5th subplots or (GE 20 percent average over all subplots, and GE 15 percent on 4/5th subplots).

(a) Mainstand conifer QMD GE 20 cm or 50 percent or more of conifer mainstand GS stocking is in trees GE 20 cm. <u>INTERMEDIATE CONIFER</u>

(b) mainstand conifer QMD LT 20 cm and LT 50 percent of conifer mainstand GS stocking is in trees GE 20 cm. <u>REGENERATION CONIFER</u>

2. Conifer mainstand GS stocking LT 25 percent on 3/5th subplots and (average mainstand stand GS stocking over all subplots LT 20 percent, or LT 4/5th subplots have GE 15 percent mainstand conifer GS stocking)

(a) Hardwood mainstand stocking GE 25 percent on 3/5th subplots--stand is hardwood

(aa) Mature(TC6) and high risk(TC4) stocking is 50 percent or more of the hardwood mainstand. <u>MATURE HARDWOOD</u>.

(bb) Mature(TC6) and high risk(TC4) stocking LE 50 percent of the hardwood mainstand.

(xa) Hardwood mainstand QMD GE 20 cm or 50 percent or more of hardwood mainstand GS stocking in trees GE 20 cm. <u>INTERMEDIATE HARDWOOD</u>.

(xb) Hardwood mainstand QMD LT 20 cm and LT 50 percent of hardwood GS stocking in trees LT 20 cm. <u>REGENERATION HARDWOOD</u>.

(b)Hardwood mainstand GS stocking LT 25 percent on 3/5th subplots.

(aa) Hardwood mainstand GS stocking plus conifer mainstand GS stocking GE 25 percent on 3/5th subplots--stand is mixed.

(xa) Mature(TC6) and high risk(TC4) stocking is 50 percent or more of conifer and hardwood mainstand GS stocking. <u>MATURE HARDWOOD/CONIFER</u>.

(xb) Mature(TC6) and high risk(TC4) stocking LT 50 percent of conifer and hardwood mainstand GS stocking.

KEY TO MANAGEMENT TYPES (continued)

(xxa) Combined hardwood and conifer mainstand QMD GE 20cm or 50 percent or more of mainstand conifer and hardwood GS stocking is in trees GE 20 cm. INTERMEDIATE HARDWOOD/CONIFER

(xxb) Combined hardwood and conifer mainstand QMD LT 20cm and LT 50 percent of mainstand conifer and hardwood GS stocking in trees GE 20 cm. REGENERATION HARDWOOD/CONIFER

(bb) Hardwood mainstand GS stocking plus conifer mainstand GS stocking LT 25 percent on 3/5th subplots. MANAGEABLE STAND ABSENT.

II. Conifer and hardwood mainstand GS stocking LT 25 percent on 3/5th subplots and average LT 20 percent over entire plot.

A. Conifer mainstand GS stocking GE 25 percent on 3/5th subplots.

1. Mainstand conifer QMD GE 20 cm or 50 percent or more of conifer mainstand GS stocking is in trees GE 20cm. INTERMEDIATE CONIFER.

2. Mainstand conifer QMD LT 20 cm and LT 50 percent of conifer mainstand GS stocking is in trees GE 20 cm. REGENERATION CONIFER.

B. Conifer mainstand GS stocking LT 25 percent on 3/5th of the subplots.

1. Hardwood mainstand GS stocking GE 25 percent on 3/5ths subplots--stand is hardwood

(a) Mature(TC6) and high risk(TC4) stocking is 50 percent or more of the hardwood mainstand. MATURE HARDWOOD.

(b) Mature(TC6) and high risk(TC4) stocking LE 50 percent of the hardwood mainstand.

(aa) Hardwood mainstand QMD GE 20 cm or 50 percent or more of hardwood mainstand GS stocking in trees GE 20 cm. INTERMEDIATE HARDWOOD.

(bb) Hardwood mainstand QMD LT 20 cm and LT 50 percent of hardwood GS stocking in trees LT 20 cm. REGENERATION HARDWOOD.

2. Hardwood mainstand GS stocking LT 25 percent on 3/5th subplots.

(a) Hardwood mainstand GS stocking plus conifer mainstand GS stocking is GE 25 percent on 3/5th subplots--stand is mixed.

(aa) Mature(TC6) and high-risk(TC4) stocking is 50 percent or more of the conifer and hardwood mainstand. MATURE HARDWOOD/CONIFER.

(bb) Mature(TC6) and high-risk(TC4) stocking LT 50 percent of the conifer and hardwood mainstand.

KEY TO MANAGEMENT TYPES (continued)

(xa) Combined hardwood and conifer mainstand QMD GE 20 cm or 50 percent or more of mainstand conifer and hardwood GS stocking in trees GE 20 cm.
INTERMEDIATE HARDWOOD/CONIFER

(xb) Combined hardwood and conifer mainstand QMD LT 20 cm and LT 50 percent of mainstand conifer and hardwood GS stocking in trees GE 20 cm.
REGENERATION HARDWOOD/CONIFER

(b) Hardwood mainstand GS stocking plus conifer mainstand GS stocking LT 25 percent on 3/5th subplots. MANAGEABLE STAND ABSENT.

STAND AGE

For all condition class plots:
Stand age is calculated for all plots where growing stock (live, non-cull) trees are present. On plots with a manageable stand of conifer present (management type = 1), stand age is based on the ages of mainstand conifer growing stock tally present. In hardwood stands (management type=2), stand age is based on the age of mainstand and residual overstory growing stock hardwoods. On plots with mixed conifer/hardwood stands (management type=3) and on plots with no manageable stand present (management type=4) stand age is based on the ages of all mainstand growing stock trees. Stand age is 99 (nonstocked) if no mainstand growing stock trees are present, or if mainstand stocking is less than 10. If Forest type=99, then Stand Age=99.

[NOTE--Use adjusted expanded unproportioned stocking and NCENT3. Include only trees from subplots whose center is in the condition class.]

Stand age is determined as follows :

(1) Adjust tree ages from breast-high to total age. Assign age 5 to seedlings, except Redwood. Assign Redwood seedlings an age=1.

(2) Group tally in 10-year age groups as 0-9, 10-19, etc.

(3) Determine the three adjacent age groups with the highest stocking of qualifying trees.

(a) If GE 70 percent of the appropriate stocking (see above) falls in three adjacent age groups, the stand is even-aged. Set stand age equal to the middle class unless more than 50 percent of the stocking falls in one of the end classes, in which case, set equal to that class. If two or more groups of age classes have equal stocking, use the older if the stand is mature or intermediate, otherwise use the younger age class.

(b) If < 70 percent of the appropriate stocking is in three adjacent age groups, the stand is uneven-aged.

(1) If the stand is uneven-aged sort growing stock trees by tree class (TC 4-6). Reclassify high risk trees (TC4) as mature (TC6) if they are 52.4 cm in DBH and either:

(a) >50 years in b.h. age and in Ecoregion 8, or

(b) >80 years bh age and not in Ecoregion 8.

High risk trees (TC4) that do not qualify as mature (TC6) will be reclassified as immature (TC5)

(2) If the stand is uneven-aged mature conifer (Mgt. type 1, stg.dev. 3), use the same procedures as in even-aged stands but consider only mature growing stock conifer (TC6) in stand age.

(3) If the stand is uneven-aged intermediate conifer (Mgt. type 1, stg.dev. 2), use the same procedures as for even-aged stands but consider only immature growing stock conifer trees (tree class 5) that are > 20 cm in d.b.h.

STAND AGE (continued)

(4) If the stand is uneven-aged regeneration conifer (Mgt. type 1, stg.dev. 1), use the same procedure as for even-aged stands but consider only immature growing stock conifer that are <20 cm in d.b.h.

(5) If the stand is hardwood (Mgt type 2), use all mainstand and residual overstory growing stock hardwoods to calculate stand age. Exclude conifers.

(6) If the stand is Mgt. type 3 or 4, use all mainstand growing stock trees to calculate stand age.

(7) If Forest Type = 99, then Stand Age is always 99.

Stand age	even-aged code	uneven-aged code
00-09	01	51
10-19	02	52
20-29	03	53
30-39	04	54
40-49	05	55
50-59	06	56
60-69	07	57
70-79	08	58
80-89	09	59
90-99	10	60
100-109	11	61
110-119	12	62
120-129	13	63
130-139	14	64
140-149	15	65
150-159	16	66
160-169	17	67
170-179	18	68
180-189	19	69
190-199	20	70
200-299	21	71
300+	22	72
Nonstocked	99	99

YEARS TO BREAST HEIGHT

The following table provides the number of years each species grows before the tree reaches breast-height size.

Species Code	Years-to-breast-height
14,16-19,22,202	8
15	20
20-21	14
41,42,98	7
81, 93	15
103-133	11
211, 213	0
242,263,264	7
351,352, 746,747	2
Other conifers	6
Other Hardwoods	7

TREATMENT OPPORTUNITY

Our objective is to identify physical opportunities to increase timber production through silvicultural manipulation of tree stocking. Although our primary interest is in physical opportunities, we hope also to obtain some of the inputs needed for economic analysis. The procedures are subject to certain constraints:

(a) Information needs must be met from FIA data.

(b) Treatment opportunity classification should be based on office evaluation of data rather than subjective field judgment in order to:(1) permit data collection by summer field assistants, (2) obtain consistent classification results, and (3) permit later reevaluation with different treatment criteria.

(c) The analytical procedures used to identify treatment opportunities should be as simple and straightforward as possible and should be applicable over a wide geographic area.

(d) Reasonable results should be expected for stands of mixed ages, mixed species and variable spacing.

These constraints make it impossible to consider all the subtleties that a trained silviculturalist might observe before prescribing for an individual stand. Our intent, however, is not to provide managers with guidance in treating individual stands but to give planners estimates of acreages available for various types of treatment. We hope to develop estimates that are as accurate as is possible within our usual budgetary and manpower limitations.

THE TREATMENTS

For treatment identification purposes, all stands are sorted into three species groups--conifers, hardwoods, and conifer/hardwood mixes--and three stages of development--mature, intermediate, and regeneration. An additional category--"no manageable stand present"--includes areas where trees are lacking or where the stocking is insufficient for reasonable management.

The treatments identified are those which can be expected to increase timber production through manipulation of growing stock. Two other common treatments--fertilization and genetic improvement--are omitted, but potential fertilization opportunities should be identifiable by combining treatment opportunity class with site index and cost information. Genetic improvement, of course, is possible wherever a planting opportunity exists.

A. Mature conifer stands

1. No treatment--Periodic annual growth of conifers is >60 percent of the mean annual growth at culmination that would be expected if a fully-stocked natural stand were growing on the site.***NOTE: These plots would be classed as harvest opportunities in Washington and Oregon.

2. Shelterwood removal cut--This is the final stage of a shelterwood cut, when the regeneration is well established and the remaining overstory can be removed. Overstory stocking should be LT 50 percent and futurestand stocking should be at least 50 percent on at least 60 percent of the area. Natural stands with a composition that resembles this description are treated in the same manner.

TREATMENT OPPORTUNITY (continued)

THE TREATMENTS

3. Regeneration harvest--This is the prescription of stands that fail to qualify for a shelterwood removal cut because of excessive overstory or inadequate understory and fail to qualify for no treatment because of low growth.

B. Intermediate conifer stands

1. Commercial thinning--An intermediate harvest in which excess growing stock is removed for sale. Stands with mainstand growing stock stocking GE 75 percent on at least 3/5ths of the subplots are candidates for commercial thinning.

2. Improvement cutting--The removal of unsaleable material in order to free crop trees from competition. Stands are candidates for this treatment if cull hardwood stocking is GE to 20 percent on 60 percent or more of the area.

3. Regeneration harvest--Intermediate stands with a conifer volume that is >5,000 bd. ft., Scribner are candidates for regeneration harvest if the gross periodic annual growth of conifers (in cubic feet) is less than 60 percent of the mean annual increment at culmination that would be expected if a fully-stocked natural stand were growing on the site.

4. Sanitation salvage--The removal of high risk trees. When the mainstand and residual stocking of high risk trees is GE 20 percent on 60 percent or more of the area, the stand is a candidate for this treatment.

C. Conifer regeneration stands (treatment opportunity is not assessed on areas that were clearcut in the past 5 years. These stands are classed as RECENT CLEARCUTS)

1. Precommercial thinning--Regeneration stands qualify for precommercial thinning, (a) if the average height of the dominant and codominant trees is between 3 and 10 meters and (b) if stocking of growing stock conifer is GE 75 percent on 60 percent of area.

2. Precommercial thinning of clumps--Stands which otherwise qualify for precommercial thinning but where at least 30 but LT 60 percent of the area exceeds 75 percent stocking.

3. Cleaning or release--A cleaning is called for when a regeneration stand is partly stocked with brush or hardwoods. If this competition overtops the conifers, the treatment is called a release. The usual treatment is to remove or kill the unwanted vegetation. Stands are candidates for treatment when competing vegetation or overtopping is coded (codes 1 or 3) on 60 percent or more of the area.

4. Prepare site and plant holes--This treatment is called for when 30 percent or more of the plot lacks conifer stocking or the overall conifer mainstand density is LT 35 percent and the average height is LE 2 m.

5. Improvement cutting--Regeneration stands under an overstory of hardwood and cull conifer trees that are GE 20 cm in d.b.h. are candidates for improvement cutting if the density of such trees is GE 20 percent on at least 60 percent of the area.

TREATMENT OPPORTUNITY (continued)

THE TREATMENTS

D. Hardwood stands, hardwood-conifer mixed stands.

In the current analysis, these stands are combined with "manageable stand absent".

E. Manageable stand absent

1. Regeneration harvest--Stands that average 5000 or more scribner board feet of sawtimber volume are candidates for clearcutting.

2. Stand conversion--Areas where a manageable stand is absent and the volume is LT 5000 bd ft. per acre, but where the density of trees GE 20cm in d.b.h. is GE 20 percent on 60 percent of the area are candidates for stand conversion. This treatment calls for removing the existing trees and planting the area with desirable growing stock.

3. Site preparation and planting--Areas where a manageable stand is absent and where stocking is inadequate for stand conversion are candidates for planting, after young hardwoods, brush, ferns slash, and other inhibiting materials have been removed.

TREATMENT CODES

Treatment Codes	Management Type
1	conifer
2	hardwood
3	mixed conifer and hardwood
4	manageable stand absent

Stage of development Codes	Stage
1	regeneration
2	intermediate
3	mature
0	used with manageable stand absent

Treatments: Codes	Options
01	no treatment
02	site preparation and planting
03	site preparation and plant holes
04	precommercial thinning
05	precommercial thinning of clumps
06	cleaning and release (none in California)
07	commercial thinning
08	improvement cutting
09	sanitation salvage
10	regeneration harvest
12	shelterwood removal cut
15	stand conversion
16	recent clearcut (no regeneration)
17	recent clearcut (partial regeneration)
24	potential precommercial thinning
27	potential commercial thinning
38	improvement cutting/site preparation and plant holes
48	improvement cutting/precommercial thinning
58	improvement cutting/precommercial thinning of clumps
68	improvement cutting/cleaning and release (none in Calif.)
99	hardwood site (none in California)

A KEY TO TREATMENT OPPORTUNITIES

[NOTE--Use adjusted expanded unproportioned stocking and NCENT3. Include only trees from subplots whose center is in the condition class.]

For mature conifer stands:

I. Scribner growing stock volume per acre <5,000 bd ft. or cubic gross current annual growth >60 percent of plot MAI capability. <u>NO TREATMENT (01)</u>

II. Scribner growing stock volume per acre >5,000 bd ft. and cubic gross current annual growth <60 percent of plot MAI capability.

A. Mainstand conifer growing stock stocking GE 50 percent on 3/5 of the subplots. <u>REGENERATION HARVEST(10)</u>

B. Mainstand conifer growing stock stocking LT 50 percent on 3/5 of the subplots.

1. Futurestand conifer growing stock stocking GE 50 percent on 3/5 of the subplots. <u>SHELTERWOOD REMOVAL (12)</u>

2. Futurestand conifer growing stock stocking LT 50 percent on 3/5 of the subplots. <u>REGENERATION HARVEST(10)</u>

For intermediate conifer stands:

I. Live mainstand stocking GE 75 percent on 3/5 of the subplots or averages GE 75 percent overall.

A. Conifer mainstand growing stock stocking GE 75 percent on 3/5 of the subplots or averages GE 75 percent overall. <u>COMMERCIAL THINNING (07)</u>

B. Conifer mainstand growing stock stocking LT 75 percent on 3/5 of the subplots and averages LT 75 percent overall.

1. Conifer mainstand/residual overstory growing stock stocking of high risk trees GE 20 percent on 3/5 of the subplots or averages GE 20 percent overall. <u>SANITATION SALVAGE (09)</u>

2. Conifer mainstand/residual overstory growing stock stocking of high risk trees LT 20 percent on 3/5 of the subplots and averages LT 20 percent overall. <u>IMPROVEMENT CUT(08)</u>

A KEY TO TREATMENT OPPORTUNITIES (continued)

II. Live mainstand stocking is LT 75 percent on 3/5 of the subplots and averages LT 75 percent overall.
- A. Conifer Scribner growing stock volume per acre >5,000 bd.ft. and conifer cubic gross current annual growth <60 percent of plot MAI capability. REGENERATION HARVEST (10)

- B. Conifer Scribner growing stock volume per acre <5,000 bd.ft. or conifer cubic gross current annual growth >60 percent of plot MAI capability. NO TREATMENT. (01)

For conifer regeneration stands:

I. (1) Conifer mainstand/futurestand growing stock stocking averages LT 35 percent overall and average height (mainstand/futurestand growing stock conifers) LT 2 m -OR- (2) Conifer mainstand/futurestand growing stock stocking EQ 0 on at least 3/10 of the subplots and average height (mainstand/futurestand growing stock conifers) LE 3 m on the remaining subplots.

- A. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm is GE 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present. IMPROVEMENT CUT/PREPARE SITE AND PLANT HOLES (38)

- B. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm is LT 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present.

  1. Most recent harvest <5 years before inventory date and kind of harvest = 1 (clearcut) or 2 (partial cut). RECENT CLEARCUT (17)

  2. Most recent harvest >5 years before inventory date. PREPARE SITE AND PLANT HOLES. (3)

II. (1) Conifer mainstand/futurestand growing stock stocking averages GE 35 percent overall or average height (mainstand/futurestand growing stock conifers) GE 2 m -AND- (2) Conifer mainstand/futurestand growing stock stocking GT 0 on at least 3/10 of the subplots or average height (mainstand/futurestand growing stock conifers) GT 3 m on the remaining subplots.

- A. Conifer mainstand/futurestand growing stock stocking GE 75 percent on 3/5 of the subplots or averages GE 75 percent overall.

  1. Average height (mainstand/futurestand growing stock conifers) GE 3 m and LE 10 m on the subplots selected in (A) above -OR- average height (mainstand/futurestand growing stock conifers) GE 3 m and LE 10 m on all subplots.

     a. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm GE 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present. IMPROVEMENT CUT/PRECOMMERCIAL THINNING (48)

     b. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm LT 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present. PRECOMMERCIAL THINNING (04)

A KEY TO TREATMENT OPPORTUNITIES (continued)

2. Average height (mainstand/futurestand growing stock conifers) LT 3 m or GT 10 m on the subplots select in (A) above -AND- average height (mainstand/futurestand growing stock conifers) LT 3 m or GT 10 m on all subplots.

a. Average height (mainstand/futurestand growing stock conifers) LT 3 m on the subplots selected in (A) above -AND- average height (mainstand/futurestand growing stock conifers) LT 3 m on all subplots. <u>POTENTIAL PRECOMMERCIAL THINNING (24)</u>

b. Average height (mainstand/futurestand growing stock conifers) GT 10 m on the subplots selected in (A) above -OR- average height (mainstand/futurestand growing s tock conifers) GT 10 m on all subplots. <u>POTENTIAL COMMERCIAL THINNING (27)</u>

B. Conifer mainstand/futurestand growing stock stocking LT 75 percent on 3/5 of the subplots and averages LT 75 percent overall.

1. Conifer mainstand/futurestand growing stock stocking is GE 75 percent and average height (mainstand/futurestand growing stock conifers) is GE 3 m and LE 10 m on 3/10 of the subplots.

a. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm GE 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present. <u>IMPROVEMENT CUT/PRECOMMERCIAL THINNING OF CLUMPS (58)</u>

b. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm LT 20 percent on 3/5 of the subplots where conifer mainstand/futurestand growing stock trees are present. <u>PRECOMMERCIAL THINNING OF CLUMPS (5)</u>

2. Mainstand/futurestand growing stock conifer stocking is LT 75 percent or average height (mainstand/futurestand growing stock conifers) is LT 3 m or GT 10 m on 3/10 of the subplots.

a. Vegetation code is 1 or 3 on 3/5 of the subplots. [NOTE--vegetation is not recorded in CA inventories]

aa. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm GE 20 percent where conifer mainstand growing stock trees are present on 3/5 of the subplots. <u>IMPROVEMENT CUTTING/CLEANING AND RELEASE (68)</u>

bb. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm LT 20 percent where conifer mainstand growing stock trees are present on 3/5 of the subplots. <u>CLEANING AND RELEASE(06)</u>

b. Vegetation code is not 1 or 3 on 3/5 of the subplots.

aa. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm GE 20 percent where conifer mainstand/futurestand trees are present on 3/5 of the subplots. <u>IMPROVEMENT CUTTING(8)</u>

bb. All live residual overstory and live hardwood mainstand stocking of trees GE 20 cm LT 20 percent where conifer mainstand/futurestand trees are present on 3/5 of the subplots. <u>NO TREATMENT(1)</u>

A KEY TO TREATMENT OPPORTUNITIES (continued)

FOR AREAS WHERE NO MANAGEABLE STAND IS PRESENT, HARDWOOD STANDS AND MIXED STANDS

I. Live mainstand/residual overstory stocking of trees GE 20 cm GE 20 percent on 3/5 of the subplots -OR- all live mainstand/residual overstory stocking GE 20 percent on 3/5 of the subplots and total mainstand QMD GE 12.5 cm.

A. Conifer Scribner growing stock volume per acre GE 5000 bd.ft.
REGENERATION HARVEST (10)

B. Conifer Scribner growing stock volume per acre LT 5000 bd.ft.
STAND CONVERSION (15)

II. Live mainstand/residual overstory stocking of trees GE 20 cm LT 20 percent on 3/5 of the subplots -AND- all live mainstand/residual overstory stocking LT 20 percent on 3/5 of the subplots or total mainstand QMD LT 12.5 cm.

A. Conifer Scribner growing stock volume per acre GE 5000 bd.ft.
REGENERATION HARVEST(10)

B. Conifer Scribner growing stock volume per acre LT 5000 bd.ft.

1. Most recent harvest <5 years before inventory date and kind of harvest = 1 (clearcut) or 2 (partial cut). RECENT CLEARCUT. (16)

2. Most recent harvest >5 years before inventory date. PREPARE SITE AND PLANT. (2)

VOLUME CALCULATIONS FOR TREES IN PRIME INVENTORIES

Cubic, board foot (Scribner log rule), and board foot (International 1/4" log rule) volumes are calculated for trees on timberland and sampled oak-woodland conditions. Cubic volume of the total stem is calculated on all trees greater than or equal to 2.5cm DBH--saplings, poletimber, and sawtimber.

Growing-stock volume is cubic volume from a 1-foot stump to a 4" top, and is calculated on all trees >= 12.5cm DBH. Softwood sawtimber volume is board-foot volume from a 1-foot stump to a 6" top and is calculated on all softwood trees >= 22.5cm DBH. Hardwood sawtimber volume is board foot volume from a 1-foot stump to an 8" top and is calculated on all hardwood trees >= 27.5cm DBH.

The log length used in board-foot calculations differs by species and location:

On the west side of Oregon and Washington--

Scribner volume is calculated using 32-foot logs for softwoods and 16-foot logs for hardwoods; and International 1/4" volume is calculated using 16-foot logs for softwoods, and 8-foot logs for hardwoods.

On the east side of Oregon and Washington and for all of California--

Scribner and International 1/4" board foot volumes are calculated using the 16-foot log rule for softwoods; for hardwoods Scribner uses the 16-foot log, while International 1/4" volume uses the 8-foot log rule.

Equations that estimate board-foot volume using the 8, 16, or 32-foot log rules include the volume of the fractional log up to the specified top diameter. The fractional log is the last log of the tree--the piece that is less than the log rule specification.

The following volumes are estimated in PRIME inventories:

CUBIC VOLUME (in cubic feet)

Type of Volume	Calculated on trees with a DBH of:	Abbreviation in equations
All softwoods and hardwoods:		
Volume of the total stem--from ground to tip	>= 2.5 cm	CVTS
Volume from a 1-foot stump to the tip	>= 2.5 cm	CVT
Volume from a 1-foot stump to a 4-inch top	>=12.5 cm	CV4
Softwood sawlog volume:		
Volume from a 1-foot stump to a 6-inch top	>=22.5 cm	CV6
Hardwood sawlog volume:		
Volume from a 1-foot stump to an 8-inch top	>=27.5 cm	CV8

BOARD FOOT VOLUME (square feet)

Type of Volume	Calculated on trees with a DBH of:	Abbreviation in equations
Softwoods:		
Scribner volume, 16-foot log rule, from a 1-foot stump to a 6-inch top (used in Eastern Ore.;Eastern Wash.;Calif.)	>= 22.5 cm (9")	SV616
Scribner volume, 32-foot log rule, from a 1-foot stump to a 6-inch top (used in Western Ore.; Western Wash.)	>= 22.5 cm (9")	SV632
International 1/4" volume, 16-foot log rule, from a 1-foot stump to a 6-inch top (used in all states)	>= 22.5 cm (9")	XINT6
Hardwoods:		
Scribner volume, 16-foot log rule, from a 1-foot stump to an 8-inch top (used in all states)	>= 27.5 cm (11")	SV816
International 1/4" volume, 8-foot log rule, from a 1-foot stump to an 8-inch top (used in all states)	>= 27.5 cm (11")	XINT8

PROCEDURES

The general procedure used to calculate these volumes is as follows: a.) estimate cubic volume first to produce CVTS, CVT, CV4, and the TARIF number; b.)estimate RATIO's from equations that require DBH and TARIF as inputs; c.) use the RATIO's to convert cubic volume to Scribner and International 1/4" board-foot volumes, and to convert from the Scribner 16-foot log rule to the Scribner 32-foot log rule.

There are three methods to calculate cubic volume--a result of different types of volume equations for each species. Each method relates to a specific group of equations; all methods produce CVTS, CVT, CV4, and TARIF. In cases where volume equations do not exist for a given species, a suitable equation will be chosen and assigned to each species. Once cubic volume is calculated, all species use the same set of equations to develop the RATIO's needed to produce the remaining volumes. The methods, equations, and ratios are all discussed below.

CUBIC VOLUME Method 1:The TARIF number is based on CVTS.
Softwood Eqns. 1,2,4,6-15,17,21,22,24
Hardwood Eqns. 1-7

1. Calculate CVTS from published or documented volume equations for the species. Total stem volume is the gross cubic volume of the bole from the ground to the tip of the tree. CVTS is calculated for all trees >= 2.5cm DBH.

2. Calculate the TARIF number from CVTS, using the equation in DNR note #27.
3. Calculate CV4 from the TARIF number and tree basal area.
4. Calculate CVT from the TARIF number and DBH.

CUBIC VOLUME Method 2:The TARIF number is based on CV4.
Softwood Eqns. 3,5,16,18-20,23

5. Calculate CV4 directly from published equations, using DBH and height.
6. Calculate the TARIF number from CV4 and tree basal area.
7. If the tree >= 6" DBH then Calculate CVTS from CV4.
8. If the tree < 6" DBH then adjust the TARIF before calculating CVTS.
9. Calculate CVT from the TARIF number and DBH.

CUBIC VOLUME Method 3:The TARIF number is based on CV8.
Hardwood Eqns. 8-20

10. Calculate CVTS, CV4, and CV8 directly from published equations;
11. Calculate TARIF from CV8.
12. Calculate CVT from CV8.

For all trees:

13.CALCULATE CONVERSION RATIOS: Once CVTS and CV4 have been estimated for all species--RATIO's are calculated directly from published equations. These RATIO's are used to convert cubic to board foot volume, and 16 to 32-foot log rules. The following conversions are made:

RATIO	VOLUME CONVERSION MADE
RC6	CV4 to CV6
RC8	CV4 to CV8 (if needed)
RS616	CV6 to SV616
RS816	SV616 to SV816
RS632	SV616 to SV632
RI6	CV6 to XINT6
RI8	XINT6 to XINT8

All equations needed to calculate volume are documented in the following pages.
Table 1 shows the citation for each equation, the species for which the equation was developed, and assigns the equation a number.
Table 2 displays a list of all possible species in PRIME's inventories and identifies which equation number has been assigned to each species. The three states inventoried by the PRIME program in Portland include: California, Oregon and Washington.

TARIF SYSTEM REFERENCES:

Charles Chambers and Bruce Foltz. 1979. The TARIF system--revisions and additions. State of Washington, Department of Natural Resources. DNR Note #27.

Charles J. Chambers and Bruce W. Foltz. 1980. Comprehensive tree-volume TARIF tables, Turnbull-Little-Hoyer, 3rd Edition. State of Washington, Department of Natural Resources, Olympia, Washington.

TABLE 1A-SOFTWOOD VOLUME EQUATION NUMBER, SPECIES DEVELOPED FOR, AND CITATION.
[These equations are used to calculate CUBIC VOLUME for Steps 1 & 5, ON PAGE 118]

EQUATION NUMBER	SOFTWOOD SPECIES	CITATION FOR THE VOLUME EQUATION
1	DOUGLAS-FIR	Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report #24. State of Washington, Department of Natural Resources, Olympia, WA. 132p. (see Weyerhaeuser Eqn. #4, page 6)
2	DOUGLAS-FIR	Summerfield, Edward. 1980. In-house memo describing equations for Douglas-fir and ponderosa pine. State of Washington, Department of Natural Resources. On file with the PNW Research Station.
3	DOUGLAS-FIR	MacLean, Colin and John M. Berger. 1976. Softwood tree-volume equations for major California species. PNW Research Note, PNW-266. Pacific Northwest Forest and Range experiment Station, Portland Oregon. 34p. (see page 4)
4	PONDEROSA PINE	Summerfield, Edward. 1980. (cited above)
5	PONDEROSA PINE	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) (see page 5)
6	W.HEMLOCK	Charles Chambers and Bruce Foltz. 1979. The TARIF system--revisions and additions. DNR Note #27. State of Washington, Department of Natural Resources. (see page 2, Log CVTS equation) (<76cm in CAL)
7	W.HEMLOCK	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Coastal Mature equation) [Data originated from Browne, J.E. 1962. Standard Cubic-foot volume tables for commercial tree species of British Columbia. British Columbia Forest Service.97p. (see page 3, Table 8, Coastal Mature Western Hemlock)] (>=76cm in CAL)

TABLE 1A-SOFTWOOD VOLUME EQUATION NUMBER, SPECIES DEVELOPED FOR, AND CITATION.
[These equations are used to calculate CUBIC VOLUME for Steps 1 & 5, PAGE 118]

EQUATION NUMBER	SOFTWOOD SPECIES	CITATION FOR THE VOLUME EQUATION
8	REDCEDAR	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Interior equation) (<80 yrs in CAL)
9	REDCEDAR	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Coastal Mature equation) (>=80 yrs in CAL)
10	TRUE FIRS	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Balsam Interior)
11	TRUE FIRS	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Balsam Coastal)
12	SPRUCE	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Sitka Spruce Interior equation) (<140yrs in CAL)
13	SPRUCE	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Sitka Spruce Mature equation) (>=140yrs in CAL)
15	LODGEPOLE PINE	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Lodgepole pine)
16	LODGEPOLE PINE	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) (see page 5)
17	MNTN. HEMLOCK	Bell, J.F., Marshall, D.D. and Johnson G.P. 1981. Tarif tables for mountain hemlock: developed from an equation of total stem cubic-foot volume. Research Bulletin #35.Forest Research Lab, School of Forestry, Oregon State University, Corvallis, OR. (see page 6)
18	SHASTA RED FIR	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) (see page 6)

TABLE 1A-SOFTWOOD VOLUME EQUATION NUMBER, SPECIES DEVELOPED FOR, AND CITATION.
[These equations are used to calculate CUBIC VOLUME for Steps 1 & 5, PAGE 118]

EQUATION NUMBER	SOFTWOOD SPECIES	CITATION FOR THE VOLUME EQUATION
19	INCENSE CEDAR	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) **(see page 6)**
20	SUGAR PINE	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) (see page 5)
21	W.JUNIPER	Chittester, Judith and Colin MacLean. 1984. Cubic-foot tree-volume equations and tables for western juniper. Research Note, PNW-420. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 8p. (see page 4)
22	W. LARCH	Brackett, Michael. 1977. (DNR rep. #24 cited above) (see British Columbia eqns., page 5, Western Larch)
23	WHITE FIR	MacLean, Colin and John M. Berger.1976. (PNW-266 cited above) (see page 5)
24	REDWOOD	Krumland, B.E. and L.E. Wensel. 1975. Preliminary young growth volume tables for coastal California conifers. Research Note #1. In-house memo. Co-op Redwood Yield Research Project. Department of Forestry and Conservation, College of Natural Resources, U of Cal, Berkeley. On file with the PNW Research Station. (see Table 1, page 4)

TABLE 1B-HARDWOOD VOLUME EQUATION NUMBER, SPECIES DEVELOPED FOR, AND THE CITATION
[These equations are used to calculate CUBIC VOLUME for Steps 1 & 10, PAGE 118]

EQUATION NUMBER	HARDWOOD SPECIES	CITATION FOR THE VOLUME EQUATION
1	ALDER	Curtis, Robert O., Bruce, David, and Caryanne VanCoevering. 1968. Volume and taper tables for red alder. US Forest Serv. Res. Pap. PNW-56. PNW Forest & Range Exp. Sta., Portland, Oregon. 35p.
2	ALDER	Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report #24. State of Washington, Department of Natural Resources, Olympia, WA. 132p. (see British Columbia eqns., page 5)
3	COTTONWOOD	Brackett, Michael. 1977. (DNR rep. #24 cited above)
4	ASPEN	Brackett, Michael. 1977. (DNR rep. #24 cited above)
5	BIRCH	Brackett, Michael. 1977. (DNR rep. #24 cited above)
6	BIGLEAF MAPLE	Brackett, Michael. 1977. (DNR rep. #24 cited above)
7	EUCALYPTUS	Colin MacLean and Tom Farrenkopf. 1983. Eucalyptus volume equation. In-house memo describing the volume equation for CVTS, to be used for all species of Eucalyptus. The equation was developed from 111 trees.On file at the PNW Research Station,Portland,OR
8	GIANT CHINQUAPIN	Pillsbury, Norman H. and Michael L. Kirkley. 1984. Equations for Total, Wood, and Saw-log Volume for Thirteen California Hardwoods. PNW Research Note, PNW-414. Pacific Northwest Research Station, Portland Oregon. 52p.
9	CALIF. LAUREL	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
10	TANOAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
11	CALIF. WHITE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
12	ENGELMANN OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
13	BIGLEAF MAPLE	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
14	CALIF. BLACK OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
15	BLUE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
16	PACIFIC MADRONE	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
17	OREGON WHITE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
18	CANYON LIVE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
19	COAST LIVE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)
20	INTERIOR LIVE OAK	Pillsbury and Kirkley, 1984. (PNW-414 cited above)

TABLE 2A--SOFTWOOD VOLUME EQUATION ASSIGNMENTS, by species, half-state, or state. The numbers inside the table correspond to an equation number in Table 1A.

SPECIES CODE	SPECIES NAME	WEST. ORE.	WEST. WASH.	EAST. ORE.	EAST. WASH.	CALIF-ORNIA
11	PACIFIC SILVER FIR	11	11	10	10	--
14	BRISTLECONE FIR	--	--	--	--	18
15	WHITE FIR	23	--	10	--	23
17	GRAND FIR	11	11	10	10	23
19	SUBALPINE FIR	11	11	10	10	18
20	CALIF RED FIR	--	--	--	--	18
21	SHASTA RED FIR	18	18	18	18	18
22	NOBLE FIR	11	11	10	10	18
41	PORT-ORFORD CEDAR	19	19	19	19	8&9
42	ALASKA-CEDAR	9	9	8	8	8&9
50	CYPRESS	--	--	--	--	19
62	CALIF. JUNIPER	--	--	--	--	21
64	WESTERN JUNIPER	21	21	21	21	21
65	UTAH JUNIPER	--	--	--	--	21
72	SUBALPINE LARCH	--	22	--	22	--
73	WESTERN LARCH	--	22	22	22	--
81	INCENSE CEDAR	19	19	19	19	19
92	BREWER SPRUCE	13	--	13	--	12&13
93	ENGELMANN SPRUCE	13	13	12	12	12&13
98	SITKA SPRUCE	13	13	--	--	12&13
101	WHITEBARK PINE	15	15	15	15	20
102	BRISTLECONE PINE	--	--	--	--	16
103	KNOBCONE PINE	15	--	15	--	16
104	FOXTAIL PINE	--	--	--	--	16
108	LODGEPOLE PINE	15	15	15	15	16
109	COULTER PINE	--	--	--	--	5
113	LIMBER PINE	15	--	15	--	16
116	JEFFREY PINE	5	--	4	--	5
117	SUGAR PINE	20	20	20	20	20
119	WHITE PINE	15	15	15	15	20
120	BISHOP PINE	--	--	--	--	16
122	PONDEROSA PINE	5	4	4	4	5
124	MONTEREY PINE	--	--	--	--	16
127	GRAY PINE (digger)	--	--	--	--	5
133	PINYON PINE	--	--	--	--	21
201	BIGCONE DOUGLAS-FIR	--	--	--	--	3
202	DOUGLAS-FIR	1	1	2	2	3
211	REDWOOD	24	--	--	--	24
212	GIANT SEQUOIA	--	--	--	--	24
231	PACIFIC YEW	9	9	8	8	8&9
242	WESTERN REDCEDAR	9	9	8	8	8&9
251	NUTMEG	--	--	--	--	8&9
263	WESTERN HEMLOCK	6	6	6	6	6&7
264	MOUNTAIN HEMLOCK	17	17	17	17	17

TABLE 2B--HARDWOOD VOLUME EQUATION ASSIGNMENTS, by species, half-state, or state. The numbers inside the table correspond to an equation number in Table 1A.

SPECIES CODE	SPECIES NAME	WEST. ORE.	WEST. WASH.	EAST. ORE.	EAST. WASH.	CALIF-ORNIA
312	BIGLEAF MAPLE	13	1	13	1	13
330	BUCKEYE	--	--	--	--	19
341	TREE OF HEAVEN	--	--	--	--	2
351	RED ALDER	1	1	1	1	2
352	WHITE ALDER	1	--	1	--	2
361	PACIFIC MADRONE	16	1	16	1	16
374	WATER BIRCH	--	--	--	--	2
376	W.PAPER BIRCH	--	1	--	1	--
431	GOLDEN CHINQUAPIN	8	1	--	1	8
492	DOGWOOD	--	1	--	1	13
510	EUCALYPTUS	1	--	--	--	7
542	OREGON ASH	14	1	14	1	14
600	WALNUT	1	1	1	--	14
631	TANOAK	10	--	--	--	10
660	APPLE	1	1	1	1	18
730	SYCAMORE	1	1	1	1	18
746	QUAKING ASPEN	1	1	1	1	4
747	BLACK COTTONWOOD	1	1	1	1	3
748	FREMONT POPLAR	--	--	--	--	3
760	CHERRY	1	1	1	1	2
801	CALIF LIVE OAK	--	--	--	--	19
805	CANYON LIVE OAK	18	--	--	--	18
807	BLUE OAK	--	--	--	--	15
811	ENGELMANN OAK	--	--	--	--	12
815	OREGON WHITE OAK	17	1	17	1	17
818	CALIF BLACK OAK	14	--	14	1	14
821	VALLEY OAK	--	--	--	--	11
839	INTERIOR LIVE OAK	--	--	--	--	20
920	WILLOW	--	--	--	1	16
981	CALIF LAUREL	9	--	--	--	9
999	OTHER TREES	1	1	1	1	17

NOTE: -- = Species does not occur in the area

VARIABLE NAMES USED IN VOLUME EQUATIONS

```
D     = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
H     = HT (M) CONVERTED TO FEET (HT/0.3048)
BA    = BASAL AREA/ACRE (DBH IN INCHES)
DLOG  = LOG BASE 10, DIAMETER,INCHES
HLOG  = LOG BASE 10, HEIGHT,FEET
DLN   = NATURAL LOG, DIAMETER, INCHES
HLN   = NATURAL LOG, HEIGHT, FEET
FC    = HARDWOOD FORM CLASS

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOTAL STEM, GROUND TO TIP
CVTS  = CUBIC FOOT VOLUME, TOTAL STEM, GROUND TO TIP
TARIF = TARIF NUMBER  (SEE DNR NOTE NO.27, P.2)

CV4   = CUBIC FOOT VOLUME, ABOVE STUMP TO A  4-INCH TOP
CV6   = CUBIC FOOT VOLUME, ABOVE STUMP TO A  6-INCH TOP (SAWLOG)
CV8   = CUBIC FOOT VOLUME, ABOVE STUMP TO AN 8-INCH TOP (SAWLOG)
CVT   = CUBIC FOOT VOLUME, ABOVE STUMP TO TIP

CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION

SV616 = SCRIBNER VOLUME--ABOVE STUMP TO A 6-INCH TOP (IN 16-FT LOGS)
SV632 = SCRIBNER VOLUME--ABOVE STUMP TO A 6-INCH TOP (IN 32-FT LOGS) (WEST-SIDE)

XINT6 = INTERNATIONAL 1/4-INCH VOLUME--ABOVE STUMP TO A 6-INCH TOP (IN 16-FT LOGS)
XINT8 = INTERNATIONAL 1/4-INCH VOLUME--ABOVE STUMP TO AN 8-INCH TOP (IN 8-FT LOGS)

RC6   = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP
RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS
RS816 = RATIO TO CONVERT SCRIBNER 6-INCH TOP TO SCRIBNER 8-INCH TOP IN 16-FT LOGS
RI6   = RATIO TO CONVERT CUBIC 6-INCH TOP TO INTERNATIONAL 1/4", 6-INCH TOP
RI8   = RATIO TO CONVERT INTERNATIONAL 1/4" 6-INCH TOP TO INT. 1/4", 8-INCH TOP
RS632 = RATIO TO CONVERT SCRIB 6-INCH TOP,16-FT LOGS TO SCRIB 6-INCH TOP,32-FT LOGS

D  = DBH/ 2.54
H  = HGT/ 0.3048
BA = D**2 * 0.005454154

TERM = ((1.033*(1.0+1.382937*EXP(-4.015292*(D/10.0))))* (BA+0.087266) - 0.174533 )

WHEN (DBH.GE.12.5)  GROWSTOCK =.TRUE.    == a growing stock tree (cubic volume)
WHEN (DBH.GE.22.5)  BOARDFOOT =.TRUE.    == a sawtimber tree     (board foot volume)
```

TARIF NUMBER CALCULATION, FROM DNR REPORT #27

```
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

====================================

SOFTWOOD VOLUME EQUATIONS

====================================

CALCULATES GROSS-CONIFER-VOLUMES, EQUATIONS ARE REFERENCED IN TABLE 1A

SOFTWOOD EQUATION # 1:

```
CVTSL = -3.21809+0.04948*HLOG*DLOG-0.15664*DLOG**2+2.02132 * DLOG +
         1.63408*HLOG - 0.16185*HLOG**2
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 2:

```
CVTSL = -6.110493 + 1.81306 * DLN + 1.083884 * HLN
CVTS = EXP(CVTSL)
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 3: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 4:

```
CVTSL = -8.521558 + 1.977243*DLN - 0.105288*HLN**2 + 136.0489/(H*H) + 1.99546*HLN
CVTS = EXP(CVTSL)
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 5: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 6:

```
CVTSL = -2.72170 + 2.00857*DLOG + 1.08620*HLOG - 0.00568*D
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 7:

```
CVTSL = -2.663834 + 1.79023*DLOG + 1.124873*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 8:

```
CVTSL = -2.464614 + 1.701993*DLOG + 1.067038*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 9:

```
CVTSL = -2.379642 + 1.682300*DLOG + 1.039712*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 10:

```
CVTSL = -2.502332 + 1.864963*DLOG + 1.004903*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 11:

```
CVTSL = -2.575642 + 1.806775*DLOG + 1.094665*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 12:

```
CVTSL = -2.539944 + 1.841226*DLOG + 1.034051*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 13:

```
CVTSL = -2.700574 + 1.754171*DLOG + 1.164531*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 15:

```
CVTSL = -2.615591 + 1.847504*DLOG + 1.085772*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 16: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 17:

```
CVTS = 0.001106485*(D**1.8140497)*(H**1.2744923)
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 18: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 19: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 20: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 21:

```
FF= 0.30708901 + 0.00086157622*H - 0.0037255243*D*H/(H-4.5)
CVTS = 0.005454154*FF*D**2 * H * (H/(H-4.5))**2
TARIF = (CVTS*0.912733) / TERM
CV4 = (CVTS + 3.48) / (1.18052 + 0.32736*EXP(-0.1*D)) - 2.948
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 22:

```
CVTSL = -2.624325 + 1.847123*DLOG + 1.044007*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

SOFTWOOD EQUATION # 23: >>>Calculate with PROCEDURE PNW266 below

SOFTWOOD EQUATION # 24:

```
CVTS = EXP(-6.2597 + 1.9967*DLN + 0.9642*HLN)
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
```

PROCEDURE PNW266 (FOR SOFTWOOD EQUATIONS ONLY)

```
Calculate cubic-foot form factors:
IF SW EQUATION # = (3) CF4=0.248569 + 0.0253524*(H/D) - 0.0000560175*(H**2/D)
IF SW EQUATION # = (5) CF4=0.402060-0.899914*(1/D)
IF SW EQUATION # =(16) CF4=0.422709 - 0.0000612236*(H**2/D)
IF SW EQUATION # =(18) CF4=0.231237 + 0.028176 * (H/D)
IF SW EQUATION # =(19) CF4=0.225786 + 4.44236*(1/H)
IF SW EQUATION # =(20) CF4=0.358550-0.488134*(1/D)
IF SW EQUATION # =(23) CF4=0.299039+ 1.91272*(1/H) + 0.0000367217*(H**2/D)

CV4 = CF4 * (0.005454154 * D**2 * H)

---------------------------------------------------
For large trees:  IF (D >= 6.0)
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
CVTS = CV4 * TERM / (BA - 0.087266)
---------------------------------------------------
For smaller trees: IF (D < 6.0)  then  SET D = 6.0
BA = 6.0**2*0.005454154

Calculate CF4 again with D set to 6.0, using equations above, and recalculate CV4,
TARIF, and, CVTS:
CV4 = CF4 * (0.005454154 * D**2 * H)
TARIF1 = (CV4 * 0.912733) / (BA - 0.087266)
TARIF = (0.5*(6.0-D)**2) + (1.0+0.063*(6.0-D)**2) * TARIF1
CVTS = TARIF * TERM
--------------------------------------------------
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5)) * TERM / 0.912733
--------------------------------------------------
IF(.NOT.GROWSTOCK) then zero out growing stock volume:CV4 = 0.0
but, keep all the other variables that have been calculated.

====================================
```

HARDWOOD VOLUME EQUATIONS

```
====================================

HARDWOOD EQUATION # (1):
D2 = D**2
H2 = H**2
Z =(H - 0.5 - D/24.0) / (H- 4.5)
Z25 = Z**2.5

F = 0.3651 * Z25 - 7.9032*Z25 *D /1000.+ 3.295*Z25*H/1000.0
- 1.9856*Z25*H*D/100000.0 - 2.9668*Z25*H2/1000000.0
+ 1.5092*Z25*H**0.5/ 1000.0 + 4.9395*Z**4*D/1000.0
-2.05937*Z**4*H/1000.0 + 1.5042*Z**33 *H*D/1000000.0
-1.1433*Z**33*H**0.5/10000.0 + 1.809*Z**41*H2/10000000.0

CVT = 0.00545415*D2*(H-4.5)* F

TARIF = (CVT * 0.912733) / ((0.9679-0.1051*0.5523**(D-1.5))
        * ((1.0330*(1.0+1.382937*EXP(-4.015292*(D/10.0))))
        * (BA+ 0.087266) - 0.174533))

CVTS = TARIF * ((1.0330*(1.0 + 1.382937*EXP(-4.015292*(D/10.0))))
       * (BA + 0.087266) - 0.174533) / 0.912733

CV4 = TARIF * (BA-0.087266) / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4

HARDWOOD EQUATION # (2):
CVTSL = -2.672775 + 1.920617*DLOG + 1.074024*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4

HARDWOOD EQUATION # (3):
CVTSL = -2.945047 + 1.803973*DLOG + 1.238853*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4
```

```
HARDWOOD EQUATION # (4):
CVTSL = -2.635360 + 1.946034*DLOG + 1.024793*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4

HARDWOOD EQUATION # (5):
CVTSL = -2.757813 + 1.911681*DLOG + 1.105403*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4

HARDWOOD EQUATION # (6):
CVTSL = -2.770324 + 1.885813*DLOG + 1.119043*HLOG
CVTS = 10.0**CVTSL
TARIF = (CVTS*0.9127
```

```
33) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4
```

HARDWOOD EQUATION # (7):

```
CVTS = 0.0016144 * D**2 * H
TARIF = (CVTS*0.912733) / TERM
CV4 = TARIF * (BA-0.087266) / 0.912733
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(D-1.5))* TERM / 0.912733
RC8=0.983-0.983*0.65**(D-8.6)
CV8=RC8*CV4
```

HARDWOOD EQUATION # (8):

```
CVTS=0.0120372263*D**2.02232*H**0.68638
CV4=0.0055212937*D**2.07202*H**0.77467
CV8=0.0018985111*D**2.38285*H**0.77105
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (9):

```
CVTS=0.0057821322*D**1.94553*H**0.88389
CV4=0.0016380753*D**2.05910*H**1.05293
CV8=0.0007741517*D**2.23009*H**1.03700
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (10):

```
CVTS=0.0058870024*D**1.94165*H**0.86562
CV4=0.0005774970*D**2.19576*H**1.14078
CV8=0.0002526443*D**2.30949*H**1.21069
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (11):

```
CVTS=0.0042870077*D**2.33631*H**0.74872
CV4=0.0009684363*D**2.39565*H**0.98878
CV8=0.0001880044*D**1.87346*H**1.62443
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (12): [no sawtimber(CV8) for engelmann oak--eqns not available]

```
CVTS=0.0191453191*D**2.40248*H**0.28060
CV4 =0.0053866353*D**2.61268*H**0.31103
CV8 = CV4
```

HARDWOOD EQUATION # (13):

```
CVTS=0.0101786350*D**2.22462*H**0.57561
CV4=0.0034214162*D**2.35347*H**0.69586
CV8=0.0004236332*D**2.10316*H**1.08584*FC**0.40017
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (14):

```
CVTS=0.0070538108*D**1.97437*H**0.85034
CV4=0.0036795695*D**2.12635*H**0.83339
CV8=0.0012478663*D**2.68099*H**0.42441*FC**0.28385
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (15):

```
CVTS=0.0125103008*D**2.33089*H**0.46100
CV4=0.0042324071*D**2.53987*H**0.50591
CV8=0.0036912408*D**1.79732*H**0.83884*FC**0.15958
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

HARDWOOD EQUATION # (16):

```
CVTS=0.0067322665*D**1.96628*H**0.83458
CV4=0.0025616425*D**1.99295*H**1.01532
CV8=0.0006181530*D**1.72635*H**1.26462*FC**0.37868
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
```

```
HARDWOOD EQUATION # (17):
CVTS=0.0072695058*D**2.14321*H**0.74220
CV4=0.0024277027*D**2.25575*H**0.87108
CV8=0.0008281647*D**2.10651*H**0.91215*FC**0.32652
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))


HARDWOOD EQUATION # (18):
CVTS = 0.0097438611*D**2.20527*H**0.61190
CV4  = 0.0031670596*D**2.32519*H**0.74348
CV8=0.0006540144*D**2.24437*H**0.81358*FC**0.43381
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))

HARDWOOD EQUATION # (19):
CVTS = 0.0065261029*D**2.31958*H**0.62528
CV4  = 0.0024574847*D**2.53284*H**0.60764
CV8=0.0006540144*D**2.24437*H**0.81358*FC**0.43381
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))

HARDWOOD EQUATION # (20):
CVTS = 0.0136818837*D**2.02989*H**0.63257
CV4  = 0.0041192264*D**2.14915*H**0.77843
CV8=0.0006540144*D**2.24437*H**0.81358*FC**0.43381
CVT = CV8 / (1.03361 - 1.59234/D - 4667.04/D**4 + ( 0.104498*H)/D**2
      + 5322.16/(D**3*H))
-----------------------------------------------------------------------

For hardwoods:
IF HT < 6.0 METERS THEN CV8=CV4  NO SAWTIMBER VOLUMES FOR TREES < 6 METERS
IF(EQN.EQ.1.AND.HT.LT.6.0.AND.DBH.LT.12.5) CVTS = CVTS * (HT/6.0)
```

RATIOS TO CONVERT CUBIC VOLUME TO BOARDFEET (SAWTIMBER)

```
B4 = TARIF / 0.912733              IF (B4.LE.0.0) THEN B4 = 0.01
-----------------------------------------------------------------------------
IF USING HARDWOOD EQN# 8-20 THEN RECALCULATE CV4 FOR THE BOARDFOOT CALCS. ONLY:
CV4 = CVT * (0.99875 - 43.336/D**3 - 124.717/D**4 + (0.193437*H)/D**3
             + 479.83/(D**3*H)  )
TARIF = (CV8 * 0.912733) / ((0.983 - 0.983*0.65**(D-8.6)) * (BA-0.087266)  )
-----------------------------------------------------------------------------
```

Ratio to convert CV4 to CV6:

```
RC6 = 0.993 - 0.993*0.62**(D-6.0)
CV6 = RC6 * CV4
```

Ratio to convert CV6 to SV616:

```
RS616L = 0.174439 + 0.117594*DLOG * ALOG10(B4) - 8.210585/D**2
        + 0.236693*ALOG10(B4)-0.00001345*B4**2-0.00001937*D**2
RS616 = 10.0**RS616L
SV616 = RS616 * CV6
```

Ratio to convert SV616 to SV632:

```
RS632 = 1.001491 - 6.924097/TARIF + 0.00001351*D**2
SV632 = RS632 * SV616
```

Ratio to convert CV6 to XINT6:

```
RI6 = -2.904154 + 3.466328*ALOG10(D*TARIF) - 0.02765985 * D - 0.00008205*TARIF**2
       + 11.29598/D**2
XINT6 = RI6 * CV6
```

Ratio to convert SV616 to SV816:

```
RS816 = 0.990 - 0.58*(0.484**(D-9.5))
SV816 = RS816 * SV616
```

Ratio to convert XINT6 to XINT8:

```
RI8 = 0.990 - 0.55*(0.485**(D-9.5))
XINT8 = XINT6 * RI8
```

```
-----------------------------------------------
Calculate the upper stem volume on all trees:    CUBUS = CV4 - CV6
-----------------------------------------------
```

Checks:

```
IF(CVTS.LT.0.0)   THEN  CVTS = 0.0
IF(CV4.LT.0.0)    THEN  CV4  = 0.0
IF(CUBUS.LT.0.0)  THEN  CUBUS = 0.0
IF(CV6.LT.0.0)    THEN  CV6 = 0.0
IF(XINT6 .LT.0.0) THEN  XINT6 = 0.0
IF TARIF is ever <= 0 then SET it equal to .01
```

GROWTH

Current annual growth on growing-stock is calculated for all live growing stock trees > 12.5 cm. Scribner board-foot growth is calculated for all live growing stock trees >22.5 cm if conifer or >27.5 cm if hardwood. The procedure is to calculate the d.b.h. and height one year ago, calculate the merchantable volume one year ago, and subtract the volume one year ago from the current volume. The remainder is current annual growth, unless the tree is an ingrowth tree. Merchantable cubic-foot ingrowth trees are trees that are now > 12.5 cm but were < 12.5 cm one year ago. The current annual cubic-foot growth for such trees is equal to their current volume. Board-foot ingrowth trees are trees that are now > 22.5 cm but were less than 22.5 cm in d.b.h. one year ago if conifers; now > 27.5 cm but were less than 27.5 cm in d.b.h. one year ago if hardwoods. The current annual board-foot growth of such trees is equal to their current board-foot volume.

DBH1YR =[(DBH_MM)2 - ASDG]1/2

Where: DBH_MM = current inventory DBH
DBH1YR = DBH last year
ASDG = Current annual squared dbh growth

HT1YR = HT3 - AHG

Where: HT3 = current inventory height
HT1YR = Height last year
AHG = Annual height growth

The equations used to calculate ASDG can be found on p. 25 of this document.

Current annual gross growth--total stem will be calculated for all growing-stock trees 2.5 cm in DBH and larger. It will be calculated in the same manner as growth on growing stock except:

(1) All growing-stock trees 2.5 cm or larger will be included.

(2) Total stem growth will be calculated by subtracting total stem volume 1-year-ago from total stem volume.

(3) Total stem ingrowth trees will be trees that reached 2.5 cm in dbh in the year preceding remeasurement.

Past periodic annual gross growth (PPAG) will be calculated, tree-by-tree, for all remeasured and reconstructed trees in condition 1, for use in the change analysis as follows:

PPAG = (volume CURRENT INVENTORY - volume PREVIOUS INVENTORY) / years between measurement.

MORTALITY

Mortality volume is the volume of growing stock trees that died between inventory occasions (tree history 5 trees that were growing stock--e.g. tree class 4-6). Periodic annual mortality volume is determined by dividing tree volume/unit area at previous inventory by the number of years between measurements and summing to plot and stratum levels.

Mortality rates (the probability of a live tree dying in any given year) have been developed for present and future use. These rates will be needed to compile the current inventory, and will be used in the future to update the current inventory. The rates were developed from measurements of ???? live and ??? dead trees in the north and central coast, from ??,??? live and ???? dead trees in eastern California and ??? live and ??? dead trees in the interior.

******Karen******

MORTALITY RATES

Use the following mortality rates for all diameters on growing stock trees.

NORTH COAST
SOFTWOODS--on timberland

Douglas-fir	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0501443	0.0218806	0.0086987
20 - 50	0.0262132	0.0073417	0.0015232
>= 50	0.0095444	0.0020037	0.0013937

Redwood	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0181818	0.0115665	0.0112466
20 - 50	0.0091065	0.0009524	0.0007246
>= 50	0.0021961	0.0006291	0.0000000

Other Softwoods	Crown Ratio Class 1 - 3	4 - 6	7 - 9
ALL AGES	0.0314863	0.0087633	0.0072254

HARDWOODS--on timberland

Tanoak	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0390909	0.0200793	0.0089143
20 - 50	0.0265842	0.0093184	0.0033860
>= 50	0.0125000	0.0045651	0.0022519

Madrone	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0469136	0.0367284	0.0311111
20 - 50	0.0343303	0.0151385	0.0033333
>= 50	0.0063291	0.0025856	0.0021645

Oaks	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 50	0.0179196	0.0087988	0.0134199
>=50	0.0101484	0.0038586	0.0018002

Other Hardwoods	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0535948	0.0240385	0.0155556
20 - 50	0.0345878	0.0167677	0.0026591
>= 50	0.0191919	0.0023641	0.0026591

MORTALITY RATES
CENTRAL COAST
SOFTWOODS--on timberland

Douglas-fir	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0501443	0.0215635	0.0086987
20 - 50	0.0262132	0.0075320	0.0014993
>= 50	0.0102626	0.0019404	0.0016385

Redwood	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0181818	0.0115665	0.0109788
20 - 50	0.0095514	0.0009058	0.0007168
>= 50	0.0030090	0.0005430	0.0002732

Other Softwoods	Crown Ratio Class 1 - 3	4 - 6	7 - 9
ALL AGES	0.0314863	0.0085915	0.0071609

HARDWOODS--on timberland

Tanoak	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0390909	0.0200793	0.0095145
20 - 50	0.0271131	0.0095105	0.0035605
>= 50	0.0179813	0.0045954	0.0025636

Oaks and Madrone	Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE < 20	0.0469136	0.0331418	0.0294872
20 - 50	0.0283479	0.0107555	0.0077692
>= 50	0.0114092	0.0037683	0.0018680

Other Hardwoods	Crown Ratio Class 1 - 3	4 - 6	7 - 9
ALL AGES	0.0340959	0.0128451	0.0043818

MORTALITY RATES
NORTH INTERIOR
SOFTWOODS--on timberland

Douglas-fir		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0133690	0.0047600	0.0071312
	>= 50	0.0069930	0.0009972	0.0012987

True firs		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0292088	0.0096462	0.0030734
	>= 50	0.0149647	0.0069939	0.0061465

Pines		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0251391	0.0069324	0.0032082
	>= 50	0.0342620	0.0062878	0.0019214

Incense Cedar and Other Softwoods		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0133609	0.0081301	0.0059975
	>= 50	0.0182323	0.0043290	0.0036855

HARDWOODS--on timberland

Black Oack		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0592885	0.0279720	0.0000000
	>= 50	0.0269360	0.0048282	0.0000000

Canyon live oak		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0662338	0.0123267	0.0022173
	>= 50	0.0165775	0.0027903	0.0000000

Other Hardwoods		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0347962	0.0122850	0.0168350
	>=50	0.0181818	0.0025608	0.0000000

MORTALITY RATES

SACRAMENT0
SOFTWOODS--on timberland

Douglas-fir		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0252120	0.0025608	0.0045164
	>= 50	0.0061728	0.0040690	0.0034237

True Firs		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 75	0.0261183	0.0099550	0.0051023
	>= 75	0.0323864	0.0229533	0.0105308

Pines		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0295152	0.0105924	0.0076493
	>= 50	0.0305736	0.0060010	0.0015239

Incense cedar and other softwoods		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0173882	0.0162169	0.0071301
	>= 50	0.0134848	0.0033220	0.0076599

HARDWOODS--on timberland

Black Oak		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0430871	0.0178202	0.0125541
	>= 50	0.0229011	0.0037428	0.0116442

Canyon Live Oak		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0454545	0.0047093	0.0000000
	>= 50	0.0213333	0.0012804	0.0000000

Other Hardwoods		Crown Ratio Class 1 - 3	4 - 6	7 - 9
AGE	< 50	0.0266234	0.0166337	0.0176364
	>=50	0.0166667	0.0060284	0.0026042

MORTALITY RATES

SOUTHERN AND SAN JOAQUIN
SOFTWOODS--on timberland

	Crown Ratio Class		
True Firs	1 - 3	4 - 6	7 - 9
ALL AGES	0.0320856	0.0163924	0.0079051

	Crown Ratio Class		
Pines	1 - 3	4 - 6	7 - 9
ALL AGES	0.0358127	0.0138751	0.0144512

	Crown Ratio Class		
Incense cedar	1 - 3	4 - 6	7 - 9
ALL AGES	0.0285714	0.0120215	0.0018365

	Crown Ratio Class		
Other Softwoods	1 - 3	4 - 6	7 - 9
ALL AGES	0.0286713	0.0042735	0.0017544

ALL HARDWOODS--on timberland

	Crown Ratio Class		
All Hardwoods	1 - 3	4 - 6	7 - 9
ALL AGES	0.0266116	0.0126913	0.0090909

MORTALITY RATES

OAK WOODLAND PLOTS

Mortality rates for trees tallied on Oak Woodland condition classes are calculated as follows:

[These rates are to be used on GLC=44 on the 11k or D grids]

Species Code for Deciduous Oaks	Crown Ratio Class 1 - 3	4 - 6	7 - 10
807,811,815,818,821	0.0514860	0.0137821	0.0041396

Species Code for Live Oaks & Laurel	Crown Ratio Class 1 - 3	4 - 6	7 - 10
839,801,805,98	0.0558430	0.0283384	0.0062238

Species Code for Other Hardwods	Crown Ratio Class 1 - 3	4 - 6	7 - 10
330,352,361,730, and other species	0.0466422	0.0214646	0.0166667

BREAST HEIGHT AGE
!!

Conifers and Eucalyptus	< 50	>= 50
Species< 300 or = 510	0.0627706	0.0100267

REMOVALS

PAST PERIODIC ANNUAL HARVEST (PPAH):

PPAH is the volume of growing stock trees harvested between inventory occasions. In condition 1 on NR,R, and C subplots, all TH 8 trees that were tree class 4-6 at previous inventory qualify. For each of these trees, the dbh must be projected from previous inventory to the year of harvest, using the annual squared dbh growth calculated earlier (see p.??). The total height should also be projected for the same time period, using the height-grow routine. These projected dimensions are used to calculate the volume-per-unit area represented by each harvested tally tree at the time of harvest. The year of harvest is recorded as a plot attribute. If no year of harvest has been recorded, it will be assumed to be the mid-point between inventory occasions. Annual harvest is obtained by dividing the volume at the time of harvest by the number of years between inventory occasions.

PAST PERIODIC ANNUAL REMOVALS OTHER THAN HARVEST: (PPAOR)

PPAOR is the volume of growing stock trees cut but not utilized between inventories. All TH 3 trees that were at least 12.5 cm in dbh at previous inventory and were tree class 4-6 qualify. These trees will not be projected. Annual cut is obtained by dividing the volume at previous inventory by the number of years between inventory occasions.

BIOMASS EQUATIONS

Procedures to Estimate Biomass for California Forests

Biomass is the weight of plant material in an ecosystem. The biomass of a tree can be divided up into many components including the stump, main bole, top, bark, and crown--branches and foliage. Tree biomass is often summarized and reported as "Aboveground Woody Biomass", "Biomass of the Merchantable Bole", and "Crown Biomass". The preferred method of estimating tree biomass would be with equations developed from biomass studies where trees are weighed and analyzed for the relationship to an easily measured variable such as DBH or Height. Due to the lack of these equations for all species and for all states, a combination of procedures and techniques must be used to arrive at reasonable estimates for the forests of California. In general, the components of California tree biomass will be calculated with:

1) equations developed in California;
2) equations developed in other states including Oregon, Washington and British Columbia--for the same or similar species, and:
3) wood density factors applied to gross, whole-tree volume. These density factors are developed from known specific gravity values for each species which are listed in the Wood Handbook, 1987.

In California, we will estimate and report the oven-dry weight of the total above ground woody biomass and merchantable bole biomass. All equation sources are on file in the California Analysts office.

DEFINITIONS

All weights are in kilograms.

Aboveground woody biomass (AGWB)= weight of total stem, bark, stump, top, and branches. Foliage, cones, fruits and roots are not included.

Weight of the Bole (BOLEWT) =

For softwoods and all hardwoods NOT using the Pillsbury volume equations:

= Weight of the bole from the ground to the tip of the tree.

For all hardwoods USING the Pillsbury volume equations:

= Weight of the bole and branches from the ground to the top of the crown (includes the bark).

Biomass of the merchantable bole (BMB)=weight of bole wood inside bark, from a 1 foot stump to a 4" top.

Biomass of the Bark (BB)= weight of bark on the tree bole.

Biomass of Live Branches (BLB)= weight of the wood and bark of live branches in the crown.

Biomass of the Foliage (BF) = weight of leaves in the crown.

BIOMASS CALCULATIONS

[all weights in kilograms]

To calculate above ground woody biomass, each of the components must be estimated separately and then totaled. The exception to this is for hardwood species that use the Pillsbury equations to estimate volume (this will be explained below).

The volume equations we use in California provide us high quality estimates of gross cubic volume for the entire aboveground tree stem (CVTS), and cubic volume of the merchantable bole (CV4) from stump to 4" top. These gross volumes are the basis for a portion of the biomass calculations below. For hardwoods that use the Pillsbury equations, CVTS is actually the cubic volume of the total stem, bark, and branches in the crown. For all other hardwoods and all softwoods, CVTS is the cubic volume of the total stem only, from ground to tip, inside bark.

The gross volume in cubic feet will be multiplied by a wood density factor in pounds/cubic foot (from the Wood Handbook and other sources) to arrive at a weight in pounds for the tree. Pounds will be converted to kilograms and stored that way in our database. Note that when the Pillsbury CVTS is converted to weight in this way, it actually equals the weight of the entire tree (AGWB).

Because of the lack of information on bark volume and density for many hardwoods, we will assume that bark and wood have a similar density and multiply by the same density factor. This is relevant to hardwoods using the Pillsbury equations that include bark in the overall volume estimate of CVTS.

To calculate the total Above Ground Woody Biomass (AGWB) for a tree:

For SOFTWOODS, and Hardwoods=746,747,748,351,352:

BOLEWT= [(CVTS * DENSFAC) / 2.2046] = Weight in kilograms

AGWB = BOLEWT + BB + BLB = Weight of tree in kilograms

Where DENSFAC = the wood density factor from the table below.
BOLEWT = weight of the bole from ground to tip, inside bark

For HARDWOODS using Pillsbury's volume equations:

BOLEWT= [(CVTS * DENSFAC) / 2.2046] = Weight in kilograms

AGWB = BOLEWT = Weight of tree in kilograms

Where DENSFAC = the wood density factor from the table below.
BOLEWT = since CVTS (total volume) from Pillsbury equations includes the volume of branches in the crown and all bark, we cannot calculate the volume of the main bole, per say. The result is that BOLEWT will equal AGWB after multiplying by the density factor.

To calculate biomass of just the MERCHANTABLE BOLE, for ALL species:

1. BMB = (CV4 * DENSFAC) / 2.2046

BIOMASS CALCULATIONS (continued)

Specific Gravity and Wood Density Factors for Softwood and Hardwood Species in California

Softwoods			Hardwoods		
		DENSFAC			DENSFAC
Spp Code	Specific Gravity	Wood Density Factor a	Spp Code	Specific Gravity	Wood Density Factor a
14	0.36	22.46	P312	0.44	27.46
15	0.37	23.09	P330	0.38	23.71
17	0.35	21.84	341	0.30	18.72
19	0.31	19.34	351	0.37	23.09
20	0.36	22.46	352	0.37	23.09
21	0.36	22.46	P361	0.69	43.06
22	0.37	23.09	374	0.30	18.72
41	0.39	24.34	376	0.00	0.00
42	0.42	26.21	P431	0.48	29.95
50	0.67	41.81	P492	0.70	43.68
62	0.54	33.70	P510	0.80	49.92
64	0.54	33.70	P542	0.50	31.20
65	0.54	33.70	P600	0.51	31.82
81	0.35	21.84	P631	0.58	36.19
92	0.35	21.84	P660	0.58	36.19
93	0.33	20.59	P730	0.46	28.70
98	0.37	23.09	746	0.35	21.84
101	0.37	23.09	747	0.31	19.34
102	0.37	23.09	748	0.31	19.34
103	0.37	23.09	P801	0.80	49.92
104	0.37	23.09	P805	0.80	49.92
108	0.38	23.71	P807	0.60	37.44
109	0.43	26.83	P811	0.60	37.44
113	0.37	23.09	P815	0.60	37.44
116	0.38	23.71	P818	0.56	34.94
117	0.34	21.22	P821	0.60	37.44
119	0.35	21.84	P839	0.80	49.92
120	0.43	26.83	P920	0.36	22.46
122	0.38	23.71	P981	0.59	36.82
124	0.35	21.84	P999	0.46	28.70
127	0.43	26.83			
133	0.37	23.09			
201,202	0.46	28.70			
211,212-OG	0.38	23.71			
211,212-YG	0.34	21.22			
231	0.67	41.81			
242	0.31	19.34			
251	0.51	31.82			
263	0.42	26.21			
264	0.42	26.21			

P = volume calculated
with a Pillsbury equation
Means that CVTS=includes
branches,stem,bark,bole.
BTS=AGWB

a) The wood density factor is a constant for each species. The factor is in lbs/ft3 and estimates Oven-Dry Weight from green volume. Our volume equations produce green standing volume, therefore VOLUME x DENSFAC = oven dry weight.

Wood density factor in kilograms/ft3 = DENSFAC/2.2046.

BIOMASS CALCULATIONS (continued)

The procedure to calculate the additional components of AGWB is outlined below:

2. BB: Calculate weight of BARK when needed--do this for trees that do not use the Pillsbury equations to estimate whole-tree volume. The bark equations below come from a variety of sources, and may require different units (cm or m) for DBH. Check the note next to each equation. These equations estimate biomass in KILOGRAMS.

BARK BIOMASS EQUATIONS

SPECIES	EQN #	EQUATION	UNITS
15	1	BB =[exp(2.1069 + 2.7271 * ln (DBH))]/1000	[DBH=cm]
17,14	2	BB = 0.6 + 16.4 * (DBH)^2 * HT	[DBH=meters, HT=meters]
19	3	BB= 1.0 + 17.2 * DBH^2 * HT	[DBH=meters, HT=meters]
20,21	4	BB =[exp(1.47146+ 2.8421 * ln (DBH))]/1000	[DBH=cm]
22	5	BB =[exp(2.79189+ 2.4313 * ln (DBH))]/1000	[DBH=cm]
98	6	BB= 1.3 + 12.6 * DBH^2 * HT	[DBH=meters, HT=meters]
93	7	BB = 4.5 + 9.3 * DBH^2 * HT	[DBH=meters, HT=meters]
202,201	8	BB = exp(-4.3103 + 2.4300 * ln (DBH))	[DBH=cm]
122,127,116, 109	9	BB = exp(-3.6263 + 1.34077*ln(DBH) +0.8567*ln(HT))	[DBH=cm, HT=meters]
117	10	BB = [exp(2.183174 + 2.6610 * ln(DBH))] / 1000	[DBH=cm]
119	11	BB = 1.2 + 11.2 * DBH^2 * HT	[DBH=meters, HT=meters]
81	12	BB = [exp(-13.3146 + 2.8594 * ln(DBH))] / 1000	[DBH=cm]
41,50,242 231,251, and other Cedars	13	BB = 0.336 + 0.00058 * (DBH^2*HT)	[DBH=cm, HT=meters]
211,212 <100cm dbh. 108,120,124, 101-104	14	BB = 3.2 + 9.1 * (DBH^2) * HT	[DBH=meters, HT=meters]
263	15	BB = exp(-4.371 + 2.259 * ln(DBH))	[DBH=cm]
62,64,65	16	BB=exp(-10.175 + 2.6333 * ln(Circum))	Circum=circumference of the stem = (dbh* pi) = cm
211,212 >= 100 cm dbh	17	BB = [exp(7.189689+ 1.5837 * ln(DBH))] / 1000	[DBH=cm]
746,747,748,	18	BB = 1.3 + 27.6 * DBH^2 * HT	[DBH=meters, HT=meters]
341,374 351,352	20	BB =exp(-4.6424 + 2.4617 * ln(DBH))	[DBH=meters, HT=meters]
264	21	BB = 0.9 + 247 * (DBH^2) * HT	[DBH=meters, HT=meters]

BIOMASS CALCULATIONS (continued)

3. BLB: Calculate weight of LIVE BRANCHES when needed--do this for trees that do not use the Pillsbury equations to estimate whole-tree volume. The branch equations below come from a variety of sources, and may require different units (cm or m) for DBH. Check the note next to each equation. These equations estimate biomass in KILOGRAMS.

LIVE BRANCH BIOMASS EQUATIONS
SOFTWOODS

SPECIES	EQN#	EQUATION	
14,15,17	1	BLB = 13.0 + 12.4 * DBH^2 * HT [DBH=meters, HT=meters]	
19	2	BLB = 3.6 + 44.2 * DBH^2 * HT [DBH=meters, HT=meters]	
20,21,22	3	BLB = exp(-4.1817 + 2.3324 * ln (DBH)) [DBH=cm]	
93	4	BLB = 16.8 + 14.4 * DBH^2 * HT [DBH=meters, HT=meters]	
98	5	BLB = 9.7 + 22.0 * DBH^2 * HT [DBH=meters, HT=meters]	
202,201	6	BLB = exp(-3.6941 + 2.1382 * ln (DBH)) [DBH=cm]	
122,127,116 109	7	BLB = exp(-4.1068 + 1.5177*ln(DBH) +1.0424*ln(HT)) [DBH=cm, HT=meters]	
117	8	BLB = exp(-7.637 + 3.3648 * ln(DBH)) [DBH=cm]	
119	9	BLB = 9.5 + 16.8 * DBH^2 * HT [DBH=meters, HT=meters]	
Cedars,41, 50, 81,251 231,211,212	10	BLB = 0.199 + 0.00381 * (DBH^2*HT) [DBH=cm, HT=meters]	(a red cedar eqn)
108, 120,124 101-104	11	BLB = 7.8 + 12.3 * DBH^2 * HT [DBH=meters, HT=meters]	(a lodgepole eqn)
263	12	BLB = exp(-4.570 + 2.271 * ln(DBH)) [DBH=cm]	
62,64,65	13	BLB=exp(-7.2775 + 2.3337 * ln(DBH * pi)) [DBH=cm]	
263	17	BLB = exp(-5.2581 + 2.6045 * ln(DBH)) [DBH=cm]	

BIOMASS CALCULATIONS (continued)

LIVE BRANCH BIOMASS EQUATIONS
HARDWOODS

SPECIES	EQN#	EQUATION
341,374,746	14	BLB = 1.7 + 26.2 * DBH^2 * HT [DBH=meters, HT=meters]
747	15	BLB = 2.5 + 36.8 * DBH^2 * HT [DBH=meters, HT=meters]
351,352 Alder:	16	Total Crown Weight= exp(-4.5648 + 2.6232(ln(DBHcm)) Foliage Fraction= 1/(2.7638 + .062(DBHcm**1.3364)) Foliage Biomass = crown weight * foliage fraction BLB = (Total Crown Weight - Foliage Biomass)

BIOMASS CALCULATIONS (continued)

To calculate biomass of the FOLIAGE:

The equations below have been assembled to estimate foliage weight for some species. Availability of foliage equations is limited-- most hardwoods have no foliage equations. Foliage will not be reported or summarized until equations for all species are available. We will not calculate foliage biomass at this time.

FOLIAGE BIOMASS EQUATIONS -- all estimate biomass in kilograms
SOFTWOODS

SPECIES	EQN#	EQUATION
14,15,17	1	BF = 10.7 + 12.4 * (DBH)^2 * HT [DBH=meters, HT=meters)
19	2	BF = 5.7 + 17.5 * DBH^2 * HT [DBH=meters, HT=meters]
20,21,22	3	BF = exp(-4.8728 + 2.1683 * ln (DBH)) [DBH=cm]
93	4	BF = 14.7 + 4.7 * DBH^2 * HT [DBH=meters, HT=meters]
98	5	BF = 7.5 + 20.1 * DBH^2 * HT [DBH=meters, HT=meters)
108,133, 120,124,	6	BF = 5.5 + 4.0 * DBH^2 * HT [DBH=meters, HT=meters)
101-104,117	7	BF = exp(-4.0230 + 2.0327 * ln(DBH)) [DBH=cm)
119	8	BF = 7.8 + 6.0 * DBH^2 * HT [DBH=meters, HT=meters]
122,109, 127,116	9	BF = exp(-3.5328 + 1.992*ln(DBH)) [DBH=cm)
202,201	10	BF = exp(-2.8462 + 1.7009 * ln(DBH)) [DBH=cm)
242,cedars 251	11	BF = 0.298 + 0.00365 * (DBH^2*HT) [DBH=cm, HT=meters)
263	12	BF = exp(-6.524 + 2.659 * ln(DBH)) [DBH=cm)
62,64,65	13	BF=exp(-4.231 + 1.5606 * ln(DBH*pi)) [DBH=cm)
264	21	BF = 4.1 + 9.1 * (DBH^2) * HT [DBH=meters, HT=meters]

BIOMASS CALCULATIONS (continued)

FOLIAGE BIOMASS EQUATIONS -- all estimate biomass in kilograms
HARDWOODS

SPECIES	EQN#	EQUATION
746	14	BF = 1.0 + 4.0 * DBH^2 * HT [DBH=meters, HT=meters)
747,748	15	BF = 1.5 + 6.5 * DBH^2 * HT [DBH=meters, HT=meters)

Other SPECIES---General formula is from Snell and Little, 1983.

BF = Foliage Biomass (kg) = Total Crown Weight * Foliage Fraction

SPECIES	EQN#	EQUATION
431	16	Total Crown Weight= exp(-3.7097 + 2.2699(ln(DBHcm)) Foliage Fraction= 1/(1.6048 + .2979(DBHcm**.6828)) BF = Crown Weight * Foliage Fraction
312	17	Total Crown Weight= exp(-2.8534 + 2.1505(ln(DBHcm)) Foliage Fraction= 1/(4.6762 + .0163(DBHcm**2.0390)) BF = Crown Weight * Foliage Fraction
361	18	Total Crown Weight= exp(-3.8941 + 2.4839(ln(DBHcm)) Foliage Fraction= 1/(1.6013 + .106(DBHcm**1.3090)) BF = Crown Weight * Foliage Fraction
631	19	Total Crown Weight= exp(-3.2304 + 2.2774(ln(DBHcm)) Foliage Fraction= 1/(1.7936 + .3031(DBHcm**.7239)) BF = Crown Weight * Foliage Fraction
351,352	20	Total Crown Weight= exp(-4.5648 + 2.6232(ln(DBHcm)) Foliage Fraction= 1/(2.7638 + .062(DBHcm**1.3364)) BF = Crown Weight * Foliage Fraction

WILDLIFE HABITAT RELATIONS
FOREST LAND TYPES

NOTE--As of 7/96, wildlife habitat has not been processed. (pb)

Wildlife habitat classifications used in California are based on the WHR (wildlife habitat relations) classification system for plant community, canopy closure, size class and canopy structure class as described for California Department of Forestry's FRRAP WHR mapping project. (See "Accuracy Assessment Task Force--background materials."). WHR types are based on four data items: a 3-digit alpha code for plant community (PLCOM), and a 1-digit numeric code for canopy closure, a 1 digit code for size class, and a single-letter alpha code for structure. Nonforest GLCs (61-69,92) are always plant community "NON" (nonforest) and canopy closure, and size class, are always 0. Copy structure on nonforest plots is coded N.

For plots that are timberland, low site, or oak woodland on the 11 K grid at both occasions, follow the standard approach for recompiling OC2 variables. For other plots that are "other forest" at both occasions, set OC3 variables equal to OC2. Flag any plot not classified at OC2 and not established at OC3. For sample kind 5 (access denied, projected--no harvest), set OC3 equal to OC2. Flag all sample kind 6 plots (access denied, projected--harvest since PREVIOUS INVENTORY).

The WHR classifications are based on the vegetation currently existing on the site. Where tree stocking is less than 10 percent because of disturbance (usually timberland sites that have been harvested), a nonstocked code is recorded.

WILDLIFE HABITAT CLASSIFICATION ALGORITHM

I. GLC= 20,41,49:

A. All live tree stocking >10 percent (forest type NE 99).

1. Primary type is conifer, secondary type is hardwood (other than red alder--351) or primary type is hardwood (other than red alder), secondary type is conifer--MONTANE HARDWOOD-CONIFER

2. Primary or secondary type is red alder(351) or secondary type is lacking.
   a. Primary or secondary type is red alder(351).
      (1) Primary type is red alder(351)--DOUGLAS-FIR
      (2) Secondary type is red alder(351)--WHR type = PRIMARY FOREST TYPE.

   b. Secondary type is absent
      (1) Primary type is hardwood
         (a) Primary type is eucalyptus(510)--EUCALYPTUS
         (b) Primary type is not eucalyptus(510)
            (aa) Primary type is w.alder, sycamore, blk.cttnwd, Fremont poplar --MONTANE RIPARIAN
            (bb) Primary type is not riparian species--MONTANE HARDWOOD

      (2) Primary type is conifer.
         (a) Primary type is mixed conifer.
            (aa) Plot is in Klamath provence
               (AAA) Plot is in ecoregion--KLAMATH MIXED CONIFER.
            (bb) Plot is not in Klamath provence
               (1a) Plot is in Ecoregion 2 or 8 - PONDEROSA PINE
               (1b) Plot is not in ecoregion 2 or 8 --SIERRAN MIXED CONIFER.

I. GLC= 20,41,49:

(b) Primary type is not mixed conifer
   (aa) Primary type is subalpine fir, Engelmann spruce, mtn. hemlock, whitebark, western white, foxtail, limber, bristlecone pine--SUB-ALPINE CONIFER
   (bb) Primary type is not subalpine species
      (1a) Primary type is Coulter pine--MONTANE CONIFER-HARDWOOD
      (1b) Primary type is not Coulter pine
         (2a) Primary type is bigcone Douglasfir --MONTANE CONIFER-HARDWOOD
         (2b) Primary type is not bigcone Douglas-fir --WHR TYPE=PRIMARY FOREST TYPE.

NOTE: KLAMATH PROVENCE INCLUDES DEL NORTE(15), HUMBOLDT(23), TRINITY (105) AND MENDOCINO(45) COUNTIES, ECOREGION 2 IN TEHAMA COUNTY(103), AND SISKIYOU(93) AND SHASTA(89) COUNTIES EAST OF I-5*

B. All live tree stocking <10 percent (forest type = 99). NONSTOCKED.

II. GLC IS 42 At previous inventory, only 1 plot was classed as 42 and it was redwood. Any new plots classed as 42 will be hand classed for WHR type

III. GLC is 43

A. Pinyon(133) stocking >10 percent and juniper(062-065) stocking <80 percent

- PINYON-JUNIPER

B. Pinyon(133) stocking <10 percent or juniper(062-065) stocking >80 percent - JUNIPER

IV. GLC is 44

A. Blue oak(807) is 50 percent or more of total stocking
  (1) Digger pine(127) stocking is >30 percent of total stocking--BLUE OAK-DIGGER PINE
  (2) Digger pine(127) stocking is <30 percent of total stocking--BLUE OAK WOODLAND

B. Blue oak(807) LE 50 percent of total stocking
  (1) Valley oak(821) is 50 percent or more of total stocking--VALLEY OAK WOODLAND
  (2) Valley oak(821) LT 50 percent of total stocking
    a. Coast live oak(801) is 50 percent or more of total stocking or, if in ecoregion 8, Oregon white oak(815) is 50 percent or more of total stocking
    --COASTAL OAK WOODLAND
    b. Coast live oak(801) LT 50 percent of total stocking and, if in ecoregion 8, Oregon white oak(815) LT 50 percent of total stocking--MONTANE HARDWOOD.

V. GLC is 45 CHAPARRAL (see CALIF.WLDHAB:DATA for chaparral classification.

VI.GLC is 47 MONTANE RIPARIAN

VII.GLC is 48 CLOSED-CONE-PINE-CYPRESS

CANOPY STRUCTURE ALGORITHM

I. GLC 20 or 49 and forest type NE 99..

A. Conifer residual overstory stockinga >10 percent and live mainstand stocking > 25 percent OR conifer mainstand stocking >10 percent and futurestand stocking >25 percent-- MULTILAYER CANOPY CONIFER

B. Conifer residual overstory stocking >10 percent not found in combination with a mainstand stocking of <25 percent AND conifer mainstand stocking of >10 percent not found in combination with a future stand live tree stocking of >25 percent
--SINGLE LAYER CANOPY CONIFER

II. GLC NE 20 or 49 or forest type is 99.

A. GLC NE 20 or 49--UNCLASSIFIED

B. GLC EQ 20 OR 49 and forest type is 99--NONSTOCKED.

WHR TREE HABITAT CODES

Tree Habitat	Code	Primary Forest Type or GLC
Subalpine conifer	SCN	FT=14,19,93,101 102,104,113,119,264
Red fir	RFR	FT=20,21,22
Lodgepole pine	LPN	FT=108
Klamath mixed conifer	KMC	FT=299(in Klamath provence)
Sierran mixed conifer	SMC	FT=299(in Sierra/Cascades),212
White fir	WFR	FT=15
Douglas-fir	DFR	(FT=202,17,98,263,41,351,299 expt KMC,SMC)
Jeffrey pine	JPN	(FT=116)
Ponderosa pine	PPN	(FT=122 except in Ecoregion 3)
Eastside pine	EPN	(FT=122 in Ecoregion 3)
Redwood	RDW	(FT=211)
Pinyon-juniper	PJ	(FT=62,65,133 W/>10% pinyon & <80%juniper)
Juniper	JUN	(FT=62,64,65 /< 10% pinyon or >80%juniper)
Closed-cone pine-cypress	CPC	(FT=50,103,120,124,251)
Aspen	ASP	(FT=746)
Montane hardwood-conifer	MHC	(FT=<300/300+,300+/<300,109,14)
Montane hardwood	MHW	(GLC=20,FT=300+but NE 351,352,542,730-748)
Blue oak woodland	BOW	(GLC=44,FT=807 or OC2 WHR=BOW.)
Blue oak-digger pine	BOP	(GLC=44,FT=804/127 OR OC2 WHR=BOP)
Valley oak woodland	VOW	(GLC=44,FT=821 or OC2 WHR=VOW)
Coastal oak woodland	COW	(GLC=44,FT=801 or OC2 WHR=COW)
Montane riparian	MRI	(GLC=47 or FT=252,542,730,747,748)

aStocking is proportioned, adjusted, condition class plot-level stocking; includes all mainstand trees plus residual overstory hardwoods if plot is hdwd. site.

CODES AND LOGIC FOR CLASSIFYING WHR AND CANOPY CLOSURE

Size Class code	DBH range(mainstand QMD)	Canopy Closure code	% mainstand stocking
1	<15 cm	1	10-24
2	15-27.4 cm	2	25-39
3	27.5-59.9 cm	3	40-59
4	60-89.9 cm	4	>60
5	>90 cm		

Canopy Structure Classes

class	code
E	even
U	multi-layer
NS	nonstocked

STRATUM WEIGHTS

The main purpose of the primary sample is to help us define the strata that exist across the inventory area. Strata are defined by a specific group of classification codes, that were collected during photo-interpretation of the PI plot. The importance or 'weight' of the stratum is equal to the proportion of PI plots within each stratum relative to the total number of plots in the inventory.

The California inventory will be compiled with a new primary sample (PI) at CURRENT INVENTORY for the North Coast only, and with the primary sample from PREVIOUS INVENTORY for the remainder of the state. Data collected at both occasions are slightly different causing some classification variables to have different names. Refer to pages 2-10 for a description of these variables.

UNIT level -- North Coast

1	OP	20	11	FI	41,42,47,49,63-92
2	OP	23,24,25	12	FI,FM	45
3	OP	44	13	FM	20
4	OP	45	14	FM	23
5	OP	41,42,47,49,63-92	15	FM	24
6	FI	20	16	FM	25
7	FI	23	17	FM	44
8	FI	24	18	FM	41,42,47,49,63-92
9	FI	25	19	WENT OUT 1	
10	FI	44	20	WENT OUT 2,3	

UNIT level -- North Interior

1	OP	21,22,23,24	17	FI	45,46
2	OP	25,26,27	18	FI	41,42,47,49
3	OP	43	19	FI	61-92
4	OP	44	20	FM	21
5	OP	45,46	21	FM	22
6	OP	41,42,47,49	22	FM	23,24
7	OP	61-92	23	FM	25
8	FI	21	24	FM	26-27
9	FI	22	25	FM	43
10	FI	23	26	FM	44
11	FI	24	27	FM	45,46
12	FI	25	28	FM	41,42,47,49
13	FI	26	29	FM	61-92
14	FI	27	30	WENT OUT	1
15	FI	43	31	WENT OUT	2,3
16	FI	44			

UNIT level -- Central Coast

1	OP,FI	21,22,23,24,25,26,27	11	FM	24
2	OP	44	12	FM	25
3	OP	45	13	FM	26
4	OP	46	14	FM	27
5	OP	41-43,47,49,61-68,92	15	FM	44
6	FI	44	16	FM	45
7	FI	45	17	FM	46
8	FI	46	18	FM	41,43,47,49,61-68,92
9	FI	61-68	19	WENT OUT	1
10	FM	21-23	20	WENT OUT	2,3

STRATUM WEIGHTS (continued)

UNIT level -- Sacramento

1	OP	21-24	16	FI	61-69,92
2	OP	25	17	FM	21
3	OP	26-27	18	FM	22
4	OP	44	19	FM	23
5	OP	45	20	FM	24
6	OP	46	21	FM	25
7	OP	41-43,47,49	22	FM	26
8	OP	61-92	23	FM	27
9	FI	21-23	24	FM	44
10	FI	24	25	FM	45
11	FI	25	26	FM	46
12	FI	26	27	FM	41-43,47,49
13	FI	27	28	FM	61-92
14	FI	44	29	WENT OUT	1,2,3
15	FI	41,42,45-49			

UNIT level -- San Joaquin

1	OP	21-24	13	FI,FM	45
2	OP	25,26,27	14	FI,FM	46
3	OP	44	15	FI,FM	41,47,48,49,61-92
4	OP	45	16	FM	21
5	OP	46	17	FM	22-23
6	OP	43,47,49	18	FM	24
7	OP	61-69,92	19	FM	25
8	FI	21-23	20	FM	26
9	FI	24	21	FM	27
10	FI	25	22	FM	43
11	FI	26-27	23	WENT OUT	1,2,3
12	FI,FM	44			

UNIT level -- Southern

1	OP	21-26	9	FM	26
2	OP	44	10	FM	44
3	OP	45	11	FM	45
4	OP	46	12	FM	46
5	OP	41,43,47-49	13	FM	41,43,47-49
6	OP	61-68,92	14	FM	61-68,92
7	FM	21-24	15	WENT OUT	1,2,3
8	FM	25			

STRATUM WEIGHTS (continued)

COUNTY level -- North Coast -- Del Norte(015)

1	FI	20,23,24,63
2	FI	25
3	FM	20,24,63-92
4	FM	25
5	WENT OUT	1,2,3

COUNTY level -- North Coast -- Humboldt (023)

1	OP	20,23,24,25	8	FM	24
2	FI	20	9	FM	25
3	FI	23	10	FI	44
4	FI	24	11	FI	41,42,45-92
5	FI	25	12	OP,FM	44
6	FM	20	13	OP,FM	41,42,45-92
7	FM	23	14	WENT OUT	1,2,3

COUNTY level -- North Coast -- Mendocino (045)

1	OP	20,23,24,25	8	OP,FI,FM	44
2	FI	20,23	9	OP	45
3	FI	24	10	FI,FM	45
4	FI	25	11	OP,FM	41,42,47,49,63-92
5	FM	20	12	FI	41,42,47,49,63-92
6	FM	23,24	13	WENT OUT	1,2,3
7	FM	25			

COUNTY level -- North Coast -- Sonoma (097)

1	OP,FI,FM	20,23,24,25	4	OP,FI,FM	45
2	OP,FI	44	5	OP,FI,FM	41,47,63-92
3	FM	44	6	WENT OUT	1,2,3

COUNTY level -- North Interior -- Lassen(035)

1	OP,FI,FM,WENTOUT	21,22,23,1	7	FI	25,26
2	OP,FM	24	8	FI	43-47
3	OP,FM	25,26	9	FI	61-68
4	OP	43-47	10	FM,WENTOUT	43-47,2
5	OP	61-68	11	FM,WENTOUT	61-92,3
6	FI	24			

COUNTY level -- North Interior -- Modoc(049)

1	OP,FM,WENTOUT	21-25,1	6	FI	25
2	OP	43	7	FI	43-68
3	OP	46-68	8	FM,WENTOUT	43,2
4	FI	21	9	FM,WENTOUT	46-68,92,3
5	FI	24			

STRATUM WEIGHTS (continued)

COUNTY level -- North Interior -- Shasta(089)

1	OP	21-27	12	FI	41,47,49
2	OP	44	13	FI	61-92
3	OP	45,46	14	FM	21
4	OP	41,43,47,49,61-92	15	FM	22-23
5	FI,FM	44	16	FM	24
6	FI	21	17	FM	25-27
7	FI	22-23	18	FM	45,46
8	FI	24	19	FM	41,43,47,49,61-92
9	FI	25	20	WENTOUT	1
10	FI	26-27	21	WENTOUT	2-3
11	FI	45,46			

COUNTY level -- North Interior -- Siskiyou(093)

1	OP	21-27	12	FI	41,42,47,49,61-68
2	OP	43	13	FM	21-23
3	OP	44	14	FM	24
4	OP	45,46	15	FM	25-27
5	OP	49,61-68	16	FM	43
6	FI	21-23	17	FM	44
7	FI	24	18	FM	45,46
8	FI	25-27	19	FM	41,42,47,49,61-92
9	FI	43	20	WENTOUT	1
10	FI	44	21	WENTOUT	2-3
11	FI	46			

COUNTY level -- North Interior -- Trinity(105)

1	OP	21-27	9	FI	26
2	OP	44	10	FI	27
3	OP	41,46,47,49,61-92	11	FI	41,46,47,49,61-68
4	FI,FM	44	12	FM	21-23
5	FI	21-22	13	FM	24
6	FI	23	14	FM	25-27
7	FI	24	15	FM	41,46,47,49,61-92
8	FI	25	16	WENTOUT	1-3

COUNTY level -- Central Coast -- Alameda(001)

1	OP,FM	26,44
2	OP,FM,WENTOUT	45,46,61-67,1,2,3

COUNTY level -- Central Coast -- Contra Costa(013)

1	FM	27,44
2	OP,FM	45,46,61-68,92
3	WENTOUT	1-3

COUNTY level -- Central Coast -- Marin (041)

1	FM,WENTOUT	21-27,1
2	OP,FM,WENTOUT	44,46,2
3	OP,FM,WENTOUT	61-68,3

STRATUM WEIGHTS (continued)

COUNTY level -- Central Coast -- Monterey(053)

1	OP,FI	21-27,44	6	FI,FM	46
2	OP	45	7	FI	61-68
3	OP	46	8	FM	21-27,44
4	OP	41,42,47,61-92	9	FM	47,61-92
5	FI,FM	45	10	WENTOUT	1-3

COUNTY level -- Central Coast -- San Benito(069)

1	OP	21-26,43	5	FM	21-26,43,44
2	OP	44	6	FM	45
3	OP	45,46	7	FM	46
4	OP	47,61-92	8	FM,WENTOUT	47,61-92,2

COUNTY level -- Central Coast -- San Luis Obispo(079)

1	OP	24,44	7	FM	23-24,43,44,49
2	OP	45,46	8	FM	45,46
3	OP	61-92		FM	61-92
4	FI	23-24,44	10	WENTOUT	2
5	FI	45,46	11	WENTOUT	3
6	FI	61-92			

COUNTY level -- Central Coast -- San Mateo(081)

1	OP,FI,FM	21-27,44
2	FI,FM	46
3	FI,FM	61-67
4	FM	45
5	WENTOUT	1-3

COUNTY level -- Central Coast -- Santa Barbara(083)

1	OP,FM	22,41,43,44	4	FM	45
2	OP	45,46	5	FM	46
3	OP	61-92	6	FM,WENTOUT	47,61-92,2,3

COUNTY level -- Central Coast -- Santa Clara(085)

1	OP,FM	21-27,44
2	OP,FM	45
3	OP,FM	46
4	OP,FM	61-92
5	WENTOUT	1-3

COUNTY level -- Central Coast -- Santa Cruz(087)

1	OP,FI,FM,WENTOUT	21-25,44,1
2	FI,FM	26
3	FI,FM	27
4	FM,WENTOUT	45,46,2
5	OP,FM	61-92

COUNTY level -- Central Coast -- Solano(095)

1	OP,FM	44
2	OP,FM,WENTOUT	46,61-92,2

STRATUM WEIGHTS (continued)

COUNTY level -- Central Coast -- Ventura(111)

1	OP,FM	44
2	OP,FM	45
3	OP,FM	46
4	OP,FM	47,61-92
5	WENTOUT	2-3

COUNTY level -- Sacramento -- Butte(007)

1	OP	21-27	7	FM	24
2	FI	21-23	8	FM	25-27
3	FI	24	9	OP,FI,FM	44
4	FI	25-27	10	OP,FI,FM,WENTOUT	45,46,2
5	FI	61-92	11	OP,FM,WENTOUT	61-92,3
6	FM	21-22			

COUNTY level -- Sacramento -- Colusa(011)

1	OP,FM	23-25,44
2	OP,FM	47,61,63,66
3	OP	45,46
4	FM,WENTOUT	45,46,2

COUNTY level -- Sacramento -- Eldorado(017)

1	OP	21-27	8	FM	21-24
2	OP	45-92	9	FM	25
3	OP,FI,FM	44	10	FM	26-27
4	FI	21-23	11	FI,FM	45-46
5	FI	24	12	FI,FM	41,42,47,61-92
6	FI	25	13	WENTOUT	1-2
7	FI	26-27			

COUNTY level -- Sacramento -- Glenn(021)

1	OP,FI,FM,WENTOUT	21-27,1
2	OP,FI,FM,WENTOUT	41,47,61-68,2,3
3	OP,FM	44
4	OP,FI,FM	45-46

COUNTY level -- Sacramento -- Lake(033)

1	OP	45-46	5	FM	25-26
2	OP,FI,WENTOUT	21-27,1	6	FM	45-46
3	FM	21-23	7	OP,FM,WENTOUT	43-44,2
4	FM	24	8	OP,FM,WENTOUT	49,61-92,3

COUNTY level -- Sacramento -- Napa(055)

1	OP,FM,WENTOUT	21-26,1	4	FM	44
2	OP,FM,WENTOUT	49,61-92,3	5	FM	45
3	OP	44-46	6	FM,WENTOUT	46,2

STRATUM WEIGHTS (continued)

COUNTY level -- Sacramento -- Nevada(057)

1	OP	21-27	5	FM	26-27
2	FI	21-27	6	OP,FI,FM	44
3	FM	21-24	7	OP,FI,FM	41,42,45,46,49,61-92
4	FM	25	8	WENTOUT	1-3

COUNTY level -- Sacramento -- Placer(061)

1	OP	21-27	6	FM	25
2	OP,FI	44	7	FM	26-27
3	OP,FI	41,45,61-92	8	FM	44
4	FI	21-27	9	FM	41,45,61-92
5	FM	21-24	10	WENTOUT	1-3

COUNTY level -- Sacramento -- Plumas(063)

1	OP,FI	21-24	6	FM	23
2	OP,FI	25-27	7	FM	24
3	OP	41-49,61-68	8	FM	25-27
4	FI	41-49,61-68	9	FM	41-49,61-68
5	FM	21	10	WENTOUT	1-3

COUNTY level -- Sacramento -- Sacramento(067)

1	FM,WENTOUT	22,44,2
2	OP,FM,WENTOUT	61-67,3

COUNTY level -- Sacramento -- Sierra(091)

1	OP,FI	21-25	5	FM,WENTOUT	21-25,1
2	OP,FI	26-27	6	FM	26-27
3	OP,WENTOUT	43-49,61-68,2,3	7	FM	41-49,61-68
4	FI	41-49,61-68			

COUNTY level -- Sacramento -- Sutter(101)

1	FM,WENTOUT	22,24,44,46,1
2	OP,FM	61-66

COUNTY level -- Sacramento -- Tehama(103)

1	OP,FM	21-27	7	FM	44
2	OP	44	8	FM	45-46
3	FI	21-24	9	OP,FI	45-46
4	FI	25	10	OP,FI,FM	47,61-92
5	FI	26-27	11	WENTOUT	1-3
6	FI	44			

COUNTY level -- Sacramento -- Yolo(113)

1	OP,FM	25,44
2	OP,FM	61-92
3	OP	45-46
4	FM,WENTOUT	45-46,2

STRATUM WEIGHTS (continued)

COUNTY level -- Sacramento -- Yuba(115)

1	OP,FI	21-26
2	FM,WENTOUT	21-26,1
3	OP,FM,WENTOUT	45,46,2
4	OP,FI,FM	44
5	OP,FI,FM,WENTOUT	61-92,3

COUNTY level -- San Joaquin -- Alpine(003)

1	OP,FM,WENTOUT	21-25,1
2	OP,FM,WENTOUT	43-46,2
3	OP,FM,WENTOUT	61-68,3

COUNTY level -- San Joaquin -- Amador(005)

1	OP,FI	21-24	5	FM	26-27
2	OP,FI	25-27	6	OP,FM	44
3	FM,WENTOUT	21-24,1	7	OP,FM	45,46
4	FM	25	8	OP,FI,FM	41,48,49,61-92

COUNTY level -- San Joaquin -- Calaveras(009)

1	OP,FI,FM,WENTOUT	21,1	7	OP,FM	25
2	OP,FI,FM,WENTOUT	41,61-92,3	8	OP,FM	26
3	OP,FI,FM	22	9	OP	44
4	OP,FI,FM	24	10	FI	25
5	OP,FI,FM	27	11	FI	26
6	OP,FI,FM	45-46	12	FM	44

COUNTY level -- San Joaquin -- Fresno (019) and Madera(039)

1	OP,FI,FM,WENTOUT	21-27,1	5	FM,WENTOUT	45,2
2	OP,FM	44	6	FM,WENTOUT	41,43,47,49,61-92,3
3	OP	45-46	7	FM	46
4	OP	61-68			

COUNTY level -- San Joaquin -- Kern(029)

1	OP,FM,WENTOUT	24,1	7	FM,WENTOUT	43,2
2	OP,FM	25	8	FM,WENTOUT	47,61-92,3
3	OP	43	9	FM	44
4	OP	44	10	FM	45
5	OP	45-46	11	FM	46
6	OP	47,61-92			

COUNTY level -- San Joaquin -- Mariposa(043)

1	OP,FM,WENTOUT	45-46,2	4	OP,FM	41,49-68
2	OP,FM	26-27	5	FI,FM,WENTOUT	21-24,1
3	OP,FM	44	6	FM	25

COUNTY level -- San Joaquin -- Merced(047)

1	OP,FM	22,44
2	OP,FM,WENTOUT	45-92,2

STRATUM WEIGHTS (continued)

COUNTY level -- San Joaquin -- Mono(051)

1	OP,FM	21-25	4	FI,FM	43,44
2	OP	43	5	FI,FM	45-92
3	OP	45-92	6	WENTOUT	1-3

COUNTY level -- San Joaquin -- San Joaquin(077)

1	FM	44
2	FM,WENTOUT	45-92,2

COUNTY level -- San Joaquin -- Stanislaus(099)

1	OP,FM	22,44
2	OP,FM,WENTOUT	45-46,2
3	OP,FM,WENTOUT	61-92,3

COUNTY level -- San Joaquin -- Kings(031) and Tulare(107)

1	OP,FI,FM,WENTOUT	21-27,1	6	FM	44
2	OP	43	7	FM	45-46
3	OP	44	8	FM,WENTOUT	43,2
4	OP	45-46	9	FM,WENTOUT	41,47-92,3
5	OP	47-92			

COUNTY level -- San Joaquin -- Tuolumne(109)

1	OP,FI	21-23	6	OP,FI,FM	45-46
2	OP,FI	24	7	FM	24-27
3	OP,FI	25-27	8	FM,WENTOUT	21-23,1
4	OP,FI	61-92	9	FM,WENTOUT	41,61-92,3
5	OP,FI,FM,WENTOUT	44,2			

COUNTY level -- Southern -- Inyo(027)

1	OP,FM	24-25
2	OP,FM	43
3	OP,FM	49-68
4	WENTOUT	2,3

COUNTY level -- Southern -- Los Angeles(037)

1	OP,FM	24-44,47
2	OP,FM	45
3	OP,FM	46
4	OP,FM	61-92
5	WENTOUT	1-3

STRATUM WEIGHTS (continued)

COUNTY level -- Southern -- Orange(059)

1	FM	44
2	FM	45
3	FM	46
4	OP,FM	61-92
5	WENTOUT	1-3

COUNTY level -- Southern -- Riverside(065)

1	OP,FM	22-25	7	FM	45
2	OP,FM	43	8	FM	46
3	OP,FM	44	9	FM	47-92
4	OP	45	10	WENTOUT	1-2
5	OP	46	11	WENTOUT	3
6	OP	61-92			

COUNTY level -- Southern -- San Bernardino(071)

1	OP	43	7	FM	45
2	OP	44-46	8	FM	46
3	OP	49-68	9	FM	41,49-68
4	FM	21-26	10	WENTOUT	1-2
5	FM	43	11	WENTOUT	3
6	FM	44			

COUNTY level -- Southern -- San Diego(073)

1	OP,FM	21-26	6	FM	44
2	OP	43-44,47-49	7	FM	45
3	OP	45	8	FM	46
4	OP	46	9	FM	43,47-92
5	OP	61-92	10	WENTOUT	1-3

<u>*Karen*</u>

<u>Karen***   Description of oak area development to be added.</u>***

APPENDIX A

OVERVIEW OF DATA PROCESSING
HISTORICAL BACKGROUND -- PREVIOUS INVENTORY

REGULAR OR MAIN INVENTORY ON THE 5.5K GRID
All plots that fell on the 5.5k grid were classified in the office or measured in the field. Only tree measurements taken on timberland plots were used for volume estimation in the main inventory. The survey unit bulletins only include volume that was calculated on timberland (GLC 20,49) plots. On all other plots including oak-woodland, pinyon-juniper, and chaparral, the classification data was used to estimate area--note: there may be tree measurements on these plots but they are not used in the 5.5k grid processing.

Strata were defined by a minimum of land class and owner group, with additional subdivision for timblerland strata (i.e. volume classes). PI points were stratified and counted according to the various stratum definitions, and multiplied by the PI expansion factor (the amount of acres a PI point is worth) to calculate the stratum area. The number of field plots in each stratum were divided into the stratum area, to arrive at a 5.5k grid expansion factor for the plot. The sum of the grouped plots provides an estimate of area for all land classes including an estimate for Oak-woodland, Pinyon-juniper, and Chaparral. This latter estimate was summarized as 'unproductive forest land' in the survey unit reports.

The need for more detailed information about the Other Forest land classes was balanced with the cost and available funds to do the sampling. To accomodate a more detailed sample, we laid a second (less intensive) grid over the top of this which amounted to about 11K grid spacing. Oak-woodland, juniper and chaparral were measured if these plots fell on the 11K. Tree data was collected on the Oak-woodland and juniper land classes, inorder to get an estimate of volume for these ecosystems. Chaparral plots had a full vegetation profile measured to characterize the condition of this ecosystem in relation to fire hazard and wildlife habitat.

The data from both sampling grids were processed as 2 separate inventories, and 2 area expansion factors were developed--one to expand the 5.5k grid data and one to expand the 11k grid data (the 11k grid data contains area and volume of Other Forest plots).

PROCESSING DATA FROM THE 11K GRID
According to the variable list for the previous inventory resource file we have an 11K grid stratification code, and an 11K grid expansion factor. The stratification code includes both public and private breakdown of 1. juniper, 2. other forest-hardwood, 3. chaparral, 4.other types of other forest.

The total stratum area for Juniper, Oak-Woodland and Chaparral is the same amount of acres calculated in the main inventory. This stratum area is considered true and without error. For the 11k grid processing, we decided on 8 stratum definitions within the Other Forest land classes. This requires that within a survey unit, the Other Forest PI points are re-stratified according to the 8 strata defined below (this stratification may have been done in the main inventory, thus total area was available for each stratum).

APPENDIX A:

Previous inventory strata used for the 11k grid:

1. Juniper (43) and Other Public
2. Juniper (43) and Private
3. Oak-Woodlands (44, 47) and Other Public
4. Oak-Woodlands (44, 47) and Private
5. Chaparral (45, 46) and Other Public
6. Chaparral (45, 46) and Private
7. Other forest GLC's (40-42, 48) and Other Public
8. Other forest GLC's (40-42, 48) and Private

The number of PI points are counted within each stratum, and divided into the known total stratum area from the main inventory. Then, count the number of plots on the 11k grid that fall in each stratum and divide through to arrive at a new '11K grid expansion factor' for the plot. This is the factor that was used to expand volume on oak-woodland or juniper plots, as well as to summarize chaparral area for the more detailed items taken on 11k grid plots.

The result is that the total Other Forest area as well as Chaparral area and Oak-Woodland area will be identical in both inventories. If we summarized area within each of the 8 groups using the original plot expansion factor, and compare it to the same summary using the 11K grid expansion factor--we should get the same totals for each stratum.

Other Forest plot on the 11K grid has 2 expansion factors because of the 2 sampling designs used to collect data. When we summarize area information, we use the 5.5k grid plot expansion factor for all plots including Other Forest. When we summarize volume information we use the 5.5k grid plot expansion factor for Timberland plots and the 11k grid expansion factor for the Other Forest plots. When we summarize the more detailed information on Chaparral, we summarizearea using the 11k grid expansion factor.

APPENDIX B

DISCUSSION ON THE DOUBLE SAMPLE FOR STRATIFICATION INVENTORY DESIGN

The inventory design is a double sample for stratification based on the design described by Cochran (1977--see pages 327-355 for a statistical description of the design). This design is sometimes referred to as a two-phase or multi-phase design. The double sample design includes two samples--a large primary sample where photo-interpretation is used to collect a small amount of data on many plots , and a smaller secondary sample where a much larger and more detailed amount of information is measured on a smaller set of ground plots. The objective of the primary sample is to estimate stratum weights, while the objective of the secondary sample is to estimate stratum means (of plot attributes like area and volume). Both samples are selected from a systematic grid. The primary sample grid is projected over an entire state and a point is randomly chosen within each square of the grid (referred to as a PI plot). The secondary sample is selected from the same grid, only at a wider interval -- resulting in one out of every 16 PI plots chosen for the secondary or double sample. For variance calculation and analysis purposes we assume that the secondary sample is a random sample within strata-- but in reality it is a systematically chosen sample to insure an even geographic distribution of field plots over all strata.

PRIMARY SAMPLE

The primary sample consists of a large number of plots selected from a permanent sample grid. These plots are transferred to aerial photographs and photo-interpreted to classify various characteristics of the plot. The classification includes things like land class, owner class, volume class, and stage of development of forest stands. This information on the primary sample, is coded and used to stratify the entire population of PI plots by sorting them into groups of plots with similar broad-scale characteristics. A set of classification codes will be used to identify each stratum. The goal of the design is to improve the accuracy of area and volume estimates by reducing variation within strata (i.e. grouping like plots). There are specific formulas for calculating statistical variance for this type of sample design and stratification procedure, and are described fully in Cochran (1977).

The primary (photo) sample has several purposes:

1. increase the sample intensity for land use classification;
2. stratify timberland into volume classes to increase the accuracy of volume estimates;
3. stratify all land into developmental classes to provide an estimate of management opportunities;
4. stratify the points into plant community types for wildlife habitat classification;
5. stratify points into resource zones; and
6. determine change in land use.

SECONDARY SAMPLE

The secondary sample is a sub-sample of all the PI plots in a given stratum. Each secondary sample grid point coincides with a primary sample grid point, on the permanent grid. The secondary sample points actually become field plots and are visited on the ground where a detailed set of measurement data are collected. The secondary sample serves as both a check on the accuracy of classifications made during the primary sample, as well as the source of measured attribute data such as volume, growth, mortality, etc. The data are combined with information from the primary sample to provide estimates of area and volume for the entire inventory area. In addition, means and variances are computed within each photo stratum from measurements taken on the field plots within that stratum. This provides an estimate of precision for the attributes of the inventory sample.

APPENDIX B:
STRATIFICATION

Stratification allows us to use information collected about the nature of the forest population, to divide the forest up into groups of similar units or plots. The result is an overall reduction in variance--an increase in precision--which produces a high quality estimate of the inventory data and the associated statistical error. In addition, by stratifying, we improve the efficiency of our design by reducing the number of field plots that must be sampled to obtain a specified level of accuracy.

Note that we do not map out the strata or work with the number of PI points inside the mapped area. Instead, we define the characteristics of the stratum through the classification codes on each PI point, sort the points by those codes, and then count the number of PI points within a specific stratum definition. Initially, all PI points are sorted by the Land Class Stratum codes and the PI owner class. If the count of field plots within a stratum is low, we may combine 1 or more strata to insure an adequate field sample in that group.

STRATUM WEIGHTS

Once the characteristics of a stratum are defined by a group of classification codes, the PI point records are sorted into the appropriate strata and counted. Each stratum in the inventory carrys a weight relative to the entire inventory area. The weight is the total number of PI points in a stratum divided by the total number of PI points in the inventory.

Stratum weight = # PI points in a stratum divided by the total PI points in inventory

All the data on field plots within a given stratum can be expanded by an amount relative to the weight the stratum holds in the inventory.

STRATUM AREA

Since the total area of the inventory is known through our area determination procedures, we use this figure along with the stratum weight to calculate the area of an individual stratum. The stratum weight is a proportion, which is multiplied by the total inventory area to produce an estimate of acres for that stratum.

Area of a Stratum = (Stratum Weight) * (Total area in the Inventory)

PLOT EXPANSION FACTORS -- WHOLE PLOT AND CONDITION CLASS PLOT

Once the area in a stratum is known, the expansion factors can easily be calculated. There are 2 steps in computing the factors. The first step is to develop an expansion factor for the 'whole field plot'. In the second step, the whole plot expansion factor is proportioned among the condition classes on the plot, to arrive at the 'condition class plot expansion factor'.

The reason for the 2 steps is because the PI classification applies to an entire PI point and is based on the area surrounding subplot 1 at the pinprick. No attempt was made to identify condition classes in the PI. Therefore, the PI point stratification must use the classification on the whole point (or whole field plot) to develop stratum weights, stratum area, and the whole plot expansion factor.

CONDITION CLASS EXPANSION FACTOR

Each whole plot record may be divided into many condition class plot records. The proportion of each condition class(CC) on a plot is calculated and entered on each condition class plot record. This proportion is simply multiplied by the whole plot expansion factor to get the CC plot expansion factor. The 'factor' is actually the amount of acres a particular CC plot represents in the inventory--this will be many thousands of acres.

APPENDIX B:
CALCULATING THE FACTORS

After field plots are sorted into the proper stratum based on their PI classification (remember that a field plot corresponds to a PI point), the number of plots are counted and divided into the area for that stratum.

Whole plot expansion factor = Area of a stratum # field plots in stratum
= # of acres or hectares a plot represents

Note: All field plots within one stratum have the same expansion factor. All per-unit-area variables calculated on a given condition class plot will be multiplied (expanded) by the whole plot expansion factor to get an estimate of what the variable represents in the inventory.

For example, the total cubic volume measured on a timberland condition class plot would be calculated as follows:

Volume per CC plot = (volume/acre) * (whole plot expansion factor)

For a given condition class on a plot:

CC plot expansion factor = (CC proportion on plot) * (Whole plot exp. factor)
NOTE--This is used to summarize area data

MISCLASSIFICATION OF PI PLOTS

The field plots are a sub-sample from the entire set of PI plots chosen in the primary sample. Initially, these field plots contain the classification determined during photo-interpretation. Occasionally, the classification of one or more items turns out to be different or incorrect--once the plot is visited on the ground. If this occurs, the field plot data are correctly coded, changing the classification (such as land class). All subsequent analyses and summaries will be affected--since classification codes will always be used from the field plot record not PI record.

How does a change in land class or other variable used in stratification affect the area and volume estimates calculated from the stratified sample? First, the total area for each stratum estimated from the original classification of the primary sample does not change. Therefore, the plot area expansion factor remains the same, as well--even though the plot may now qualify to be in a different stratum.

Misclassifications of the primary sample are accounted for during analysis and summary of the field data. Plots that have changed land class, for example,will be summarized with other plots falling in the new land class. This means that, in effect, acres are being taken out of the land class in the original stratum (because the plot expansion factor remains the same) and added to the area of the correct land class, identified in the field. By simply changing the land class code in the field plot data, we are allowing the double sample to adjust for errors found in the primary sample.

Since the goal of stratification is to group similar plots in order to reduce within-stratum variance--we would expect a higher variation in strata where misclassifications occurred. The formula to calculate variance of a particular attribute looks at the field plots within the original strata. If a timberland stratum includes a plot that changed land class--i.e. from timberland to nonforest--then one plot would have zero volume while the rest of the plots would have some positive volume that was measured. Obviously, a stratum like this will have a higher variance associated with any of the measured attributes (area, volume, number of trees, etc.). When we present the statistical error in the station's inventory reports, it reflects both the variation of the population as well as the error associated with misclassification.

APPENDIX C

AN EXAMPLE OF BASIC CALCULATIONS FOR A DOUBLE SAMPLE FOR STRATIFICATION INVENTORY DESIGN

An inventory was completed on 1 million acres of land in western Oregon. The land included both forest and nonforest areas. The inventory sampling design was a double sample for stratification--the classifications used to define strata were land class and timberland volume class. After classifiying the PI plots on aerial photos, 4 strata were identified in the primary sample data:

1. Nonforest
2. Forest--unproductive ('other forest')
3. Forest--productive timberland--low volume
4. Forest--productive timberland--high volume

Point and plot count for both the PI and the second sample (field plots) along with the calculated stratum weights are shown in the following table:

Strata description	PI point	Field plot count	Stratum Weight count (PIcount/Total count)
1. Nonforest	100	10	100 / 4,000 = .025
2. Forest--unproductive	400	50	400 / 4,000 = .100
3. Forest--timberland--low volume	1,500	100	1,500 / 4,000 = .375
4. Forest--timberland--high volume	2,000	500	2,000 / 4,000 = .500
TOTAL PLOT COUNT:	4,000	660	

To calculate the area within each stratum:

Strata description	Stratum Area (stratum weight * total area in inventory)
1. Nonforest	.025 * 1,000,000 = 25,000 acres
2. Forest--unproductive	.100 * 1,000,000 = 100,000 acres
3. Forest--timberland--low volume	.375 * 1,000,000 = 375,000 acres
4. Forest--timberland--high volume	.500 * 1,000,000 = 500,000 acres

To calculate the area each whole plot represents:

Strata description	Whole Plot Expansion Factor (stratum area / # field plots)
1. Nonforest	25,000 acres / 10 = 2,500 acres
2. Forest--unproductive	100,000 acres / 50 = 2,000 acres
3. Forest--timberland--low volume	375,000 acres / 100 = 3,750 acres
4. Forest--timberland--high volume	500,000 acres / 500 = 1,000 acres

If volume per acre on a plot in stratum 4 was calculated to be 1000 cubic feet/acre then volume = 1000 cuft/acre * 1,000 acres = 1 million cubic feet.

APPENDIX C

Condition Class plot expansion factors

Each condition-class sampled on a subplot is mapped and the proportion of the subplot occupied by a condition class is determined by counting dots on a subplot diagram. The total proportion on the plot is used to divide up the area each whole plot represents.

If Plot 123 has two condition classes sampled over the 5 subplots and the map of each subplot shows the proportions listed in the table below, the condition class expansion factors can be calculated as follows: -In this example, each whole subplot is worth 1/5th or 20% of the full plot. Either an average of the proportions can be calculated, or the proportion on each subplot can be multiplied by 20% (1/5) and then summed to arrive at the final proportion for each condition class.

Subplot number	Method 1 Proportion Condition class 1	Proportion Condition class 2	Method 2 Proportion of CC 1 by subplot	Proportion of CC 1 by subplot
1	.40	.60	.4 * 1/5=.08	.6 * 1/5= .12
2	.20	.80	.2 * 1/5=.04	.8 * 1/5= .16
3	.50	.50	.5 * 1/5=.10	.5 * 1/5= .10
4	.90	.10	.9 * 1/5=.18	.1 * 1/5= .02
5	.60	.40	.6 * 1/5=.12	.4 * 1/5= .08
	2.60	2.40	Total = .52	Total = .48

Proportions in each CC
2.6/5 = .52
2.4/5 = .48 |

For the entire plot, condition class 1 makes up 52% of the plot, and condition class 2 covers 48% of the plot.

If this plot is in Stratum 3 -- Timberland,low volume -- then:

Condition Class 1 plot expansion factor = 3,750 * .52 = 1,950 acres

Condition Class 2 plot expansion factor = 3,750 * .48 = 1,800 acres

Note: you may not always divide by 5 subplots. See the Number of Subplots document for more information